Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

FEBRUARY, 1949 TECHNOLOGY DEPARTMENT

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P.R.W

Well over 300,000 miles of highway could have been paved with the strip produced by America's steel mills last year. Phoenix Rolls played an important part in this amazing record.

Pittsburgh Rolls Alloy Iron *Work Rolls* and Alloy Steel *Back-up Rolls* in four-high strip mills are rolling steel, aluminum, brass, copper, and magnesium, and are successfully producing flat-rolled products *at less cost per ton of steel rolled.*

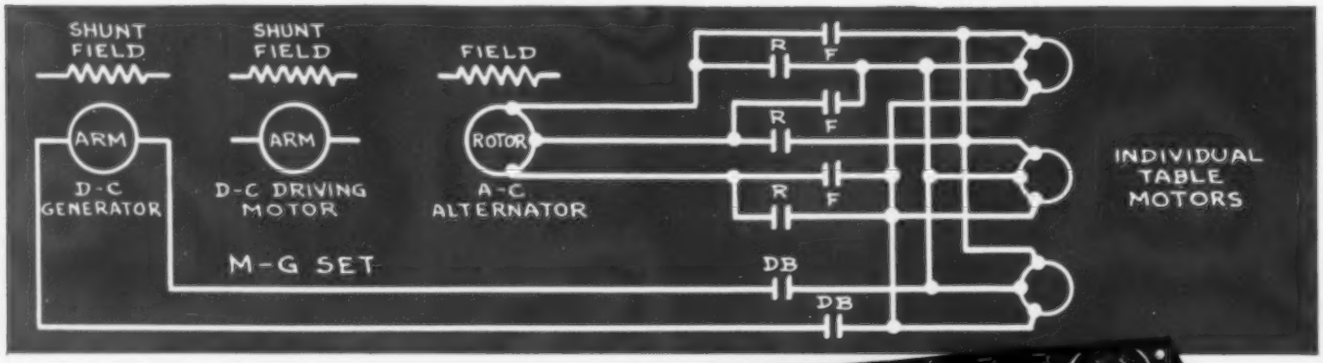
PITTSBURGH ROLLS • Division of Blaw-Knox Company • Pittsburgh 1, Pa.

PITTSBURGH ROLLS

What control for what mill equipment?

One of a SERIES

of advertisements featuring basic heavy duty power circuits . . . and showing Cutler-Hammer's broad design and application experience which has made it the preferred control for the steel industry.



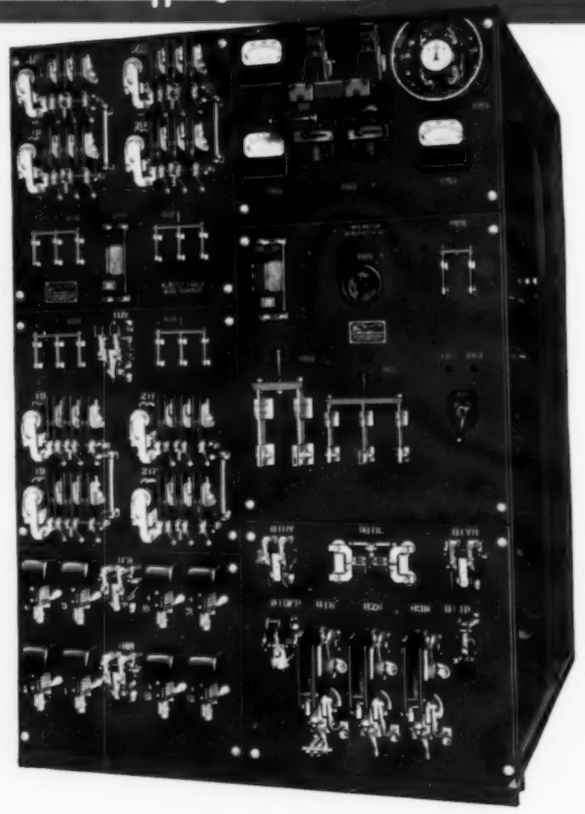
In an installation requiring individual squirrel cage motors supplied by an adjustable frequency motor generator set...

Let your choice be a . . . . . CUTLER-HAMMER Custom-Built Adjustable Frequency Control

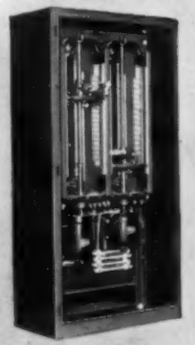
Individual motor drives have proven their superiority for hot strip mill runout table rolls. Where squirrel cage motors are used with an alternating current adjustable frequency motor generator set, Cutler-Hammer control specialists have developed an adjustable frequency controller that provides any combination of the following functions:

(a) Starting by frequency control, all motors being connected to the alternator at low frequency and accelerated by raising the frequency.
(b) Group starting, i.e., by connecting successive groups of motors to the alternator which is running at operating frequency.
(c) Field forcing of alternator for maximum starting torque.
(d) Changes in linear speed of the hot strip by adjusting the frequency of the alternator.
(e) Jogging forward or reverse.
(f) Quick stop by plugging or by applying low voltage direct current to one phase for dynamic braking.
(g) Pre-selection of running speeds.

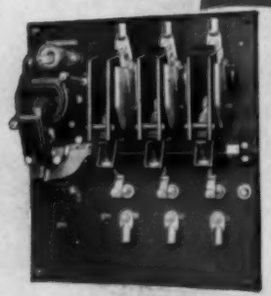
For further information, write CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.



Typical Components of CUTLER-HAMMER Mill Control



Rheostat for adjustable frequency controller



300 Ampere A-c Magnetic Contactor

Control desk with sloping top and slanted front.

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 26, No. 2.

Exclusive with...

Aetna-Standard

triple drawing of tubes

Figure with your own pencil the multiple production and cost-cutting advantages of drawing three tubes simultaneously!

Production with triple draw will be 2½ to 3 times as great as with your present single draw methods. This has been proven by the many triple tube drawbenches now in operation.

Benches now in operation are drawing tubes 1/8" to 3" diameter with a pulling capacity of 1000 lbs. to 100,000 lbs. Lengths of draw are up to 160 ft. Triple drawbenches with up to 300,000 lbs. pull are now being offered by Aetna-Standard.

Triple drawing of tubes is an exclusive development of Aetna-Standard. Write us for more about triple drawing.

THE AETNA-STANDARD ENGINEERING COMPANY
YOUNGSTOWN, OHIO

ASSOCIATED COMPANIES:
HEAD, WRIGHTSON & COMPANY, LTD., THORNABY-ON-TEES, ENGLAND
AETNA-STANDARD ENGINEERING COMPANY, LTD., TORONTO, ONTARIO, CANADA

DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries

40 YEARS

OF RELIABLE PERFORMANCE

BEHIND THE NATIONAL NAME

The unquestioned acceptance of National Rolls throughout the steel industry is ample proof of their reliability in service and of our experience in making them right!

National today, with additional facilities and the most modern equipment, is better prepared to furnish durable, strong, precision-finished iron and alloy iron rolls that meet your most rigid specifications.

National Rolls

THE NATIONAL ROLL & FOUNDRY CO.

AVONMORE, PENNSYLVANIA

SPECIALISTS IN IRON AND ALLOY IRON ROLLS

assure SMOOTHER-ROLLING ROLL NECKS

by keeping circulating systems clean with Texaco Regal Oils

Higher production . . . less servicing . . . lower maintenance costs — these are the benefits you can expect when you protect oil film roll necks with *Texaco Regal Oils* in the circulating system.

Texaco Regal Oils are turbine grade — resist oxidation, emulsification, and sludging. They stand up under high heat and speeds, and carry heavy loads easily. Thus, they keep circulating systems clean, bearings cool and fully protected against wear, roll necks rolling smoothly and efficiently.

To protect heavy-duty enclosed gears, use *Texaco Meropa Lubricants.* They have high load-carrying capacity . . . fully protect and greatly prolong the life of gears and bearings.

Use Texaco Products and Lubrication Engineering Service to increase efficiency and lower costs throughout your plant. Just call the nearest of the more than 2300 Texaco Wholesale Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

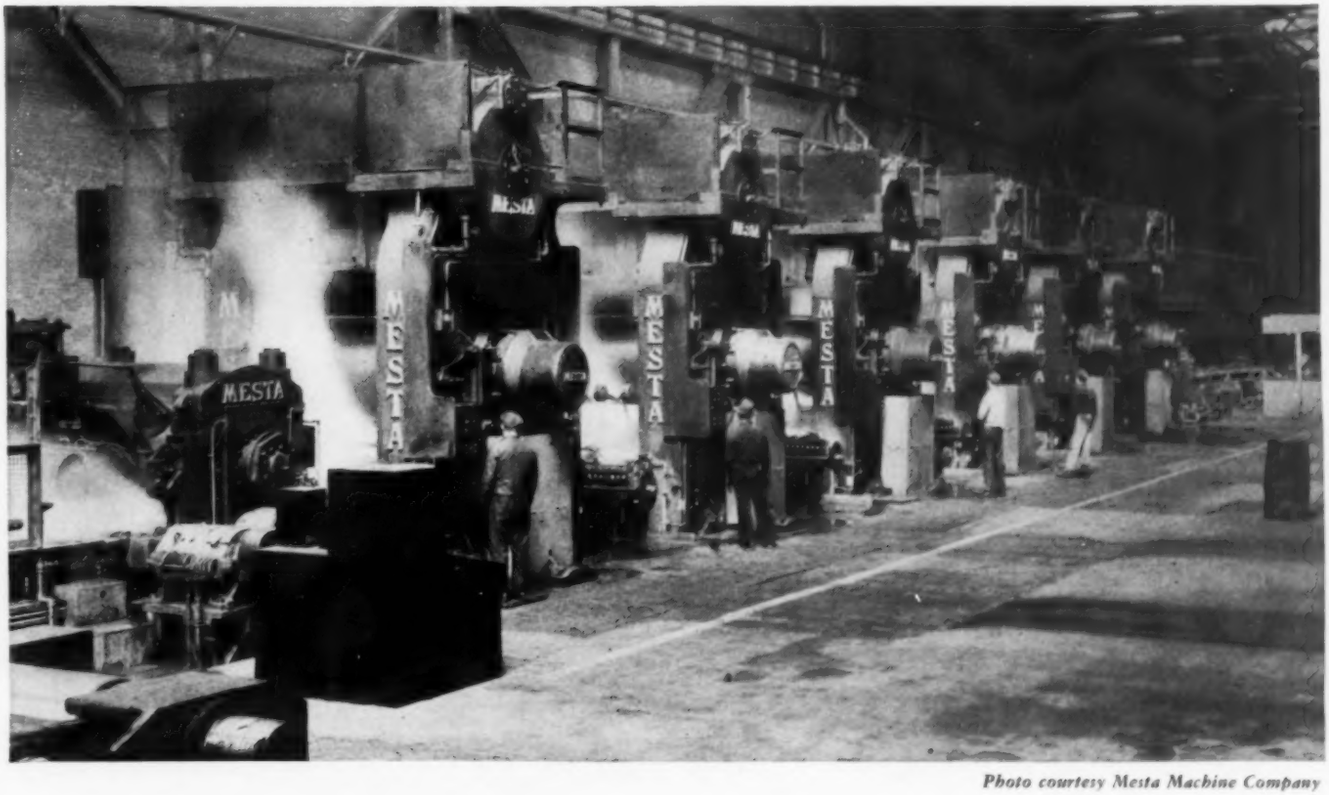


Photo courtesy Mesta Machine Company

TEXACO

TEXACO Regal Oils

(HEAVY CIRCULATING OILS)

Tune in . . . TEXACO STAR THEATRE presents MILTON BERLE every Wednesday night. METROPOLITAN OPERA broadcasts every Saturday afternoon

PRODUCTION UP . . . CONDITIONING COSTS DOWN

Plant records talk like this: *"battery of four Bonnot Billeteers process average of 54,000 tons per machine . . . total of 216,000 tons per year."*

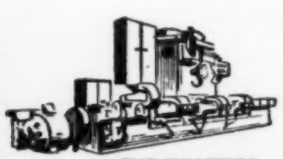
This typical Billeteer schedule was maintained in routine production. Just one man operated each machine per 8-hour shift, without the fatigue and cost that accompanies hand-cleaning methods. Daily tonnage varied according to steel condition, with Billeteers cutting out shallow imperfections or deep flaws with perfect ease. Size of billets handled ranged from 6" x 6" to 12" x 12".

In your plant, too, the "45 tons of machine power" supplied by a Bonnot Billeteer can take on the heavy billet-cleaning load at savings up to 56% as proved by actual production results.

Would you like to see a Billeteer in operation? A note addressed to our Billeteer Division will bring a list of plants where you, too, can see Billeteers biting big chunks out of billet-conditioning costs.

Engineered for Improved Production

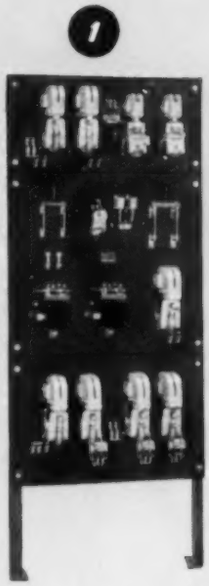
The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO

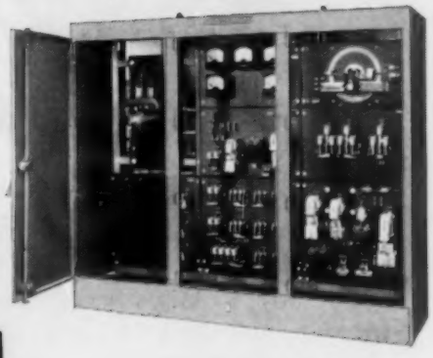


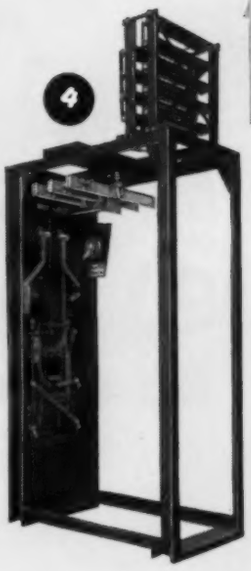
THE BILLETEER

ALSO MANUFACTURERS OF SAWING · CRUSHING · PULVERIZING & MIXING EQUIPMENT

STANDARD AND SPECIAL
HEAVY-DUTY D.C. MILL AUXILIARY & CRANE CONTROL







1 Dynamic Lowering Control Panel for cab-operated crane hoist. New network system gives surer hook control with only nine contactors. ***STANDARD***

2 Steel Mill Auxiliary Controller for reversing, dynamic braking service. Features include automatic acceleration by pneumatic timers, mill type overload relays, heavy duty control relays and contactors. ***STANDARD***

3 Variable Voltage Controller for continuous strip process line. With motor-operated field rheostat. ***SPECIAL***

4 Sectionalized Mill Control Panel with frame, line bussing, resistor bank. ***SPECIAL***

5 Benchboard and Control Cubicle for leveler and shear. Combination A.C. and D.C. control. ***SPECIAL***

Do you have a Control Problem?

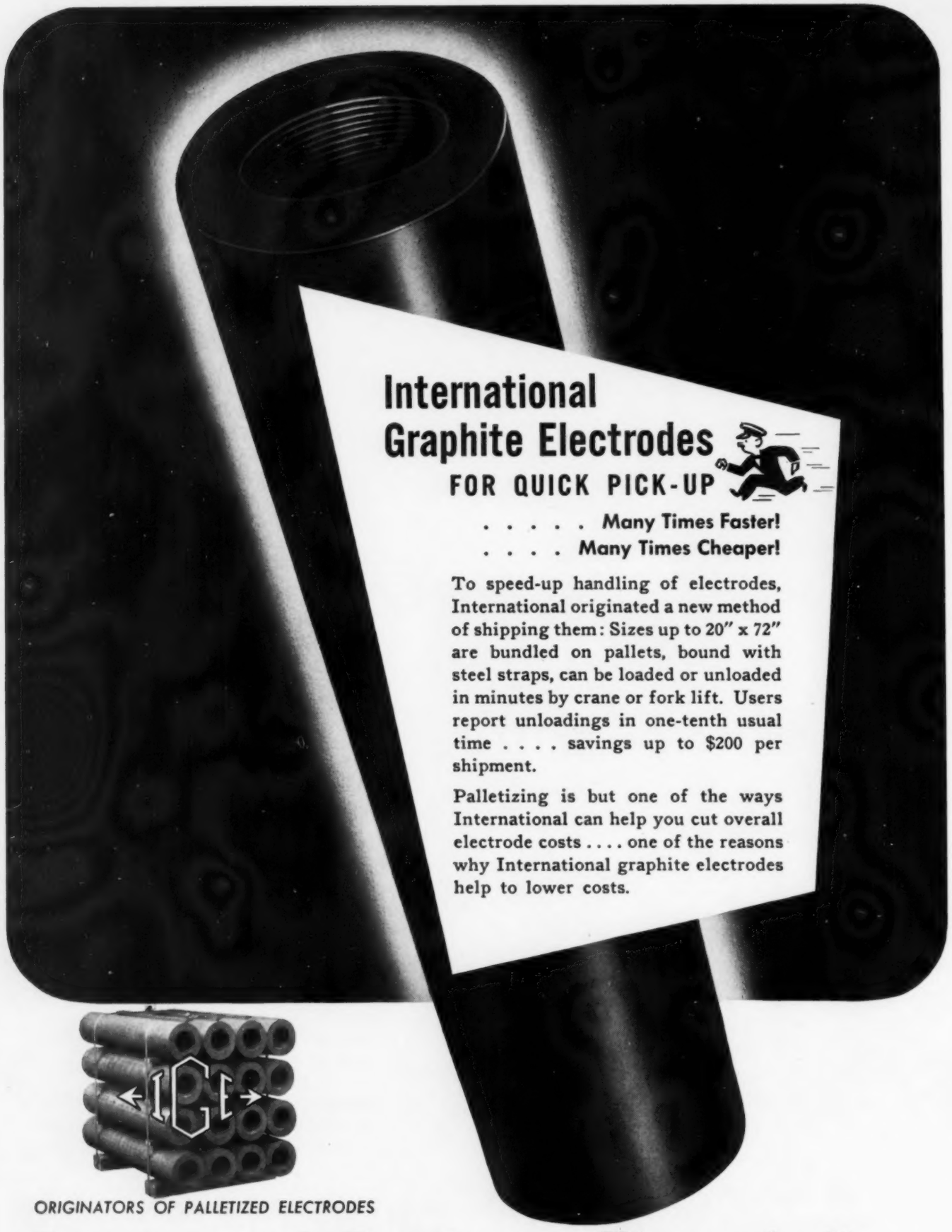
Trained Field Engineers are at your service through Square D offices in more than 50 principal cities.

Contact the nearest Square D Field Office or write direct to the Square D Company, 4041 N. Richards Street, Milwaukee 12, Wis.

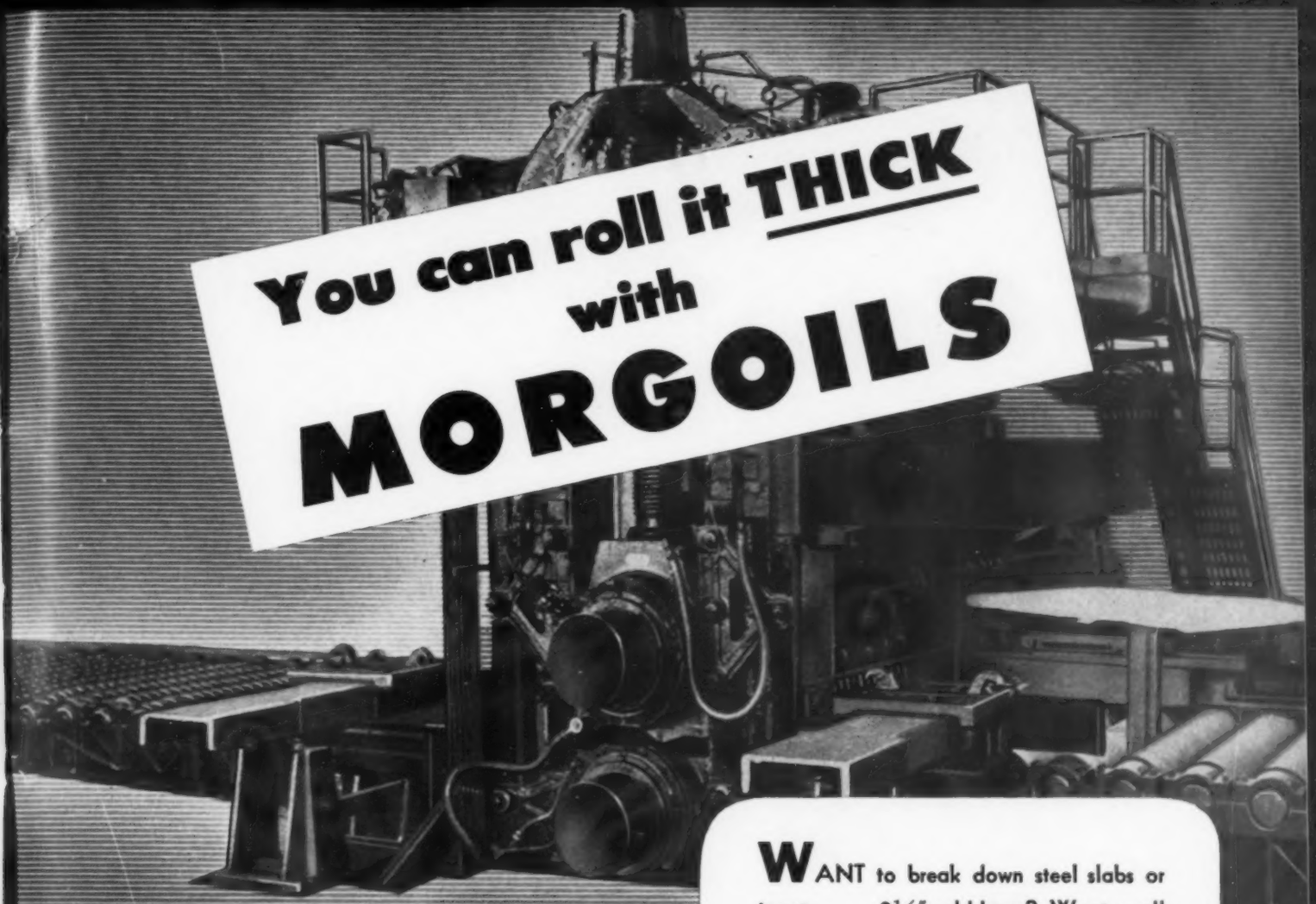
SQUARE D COMPANY

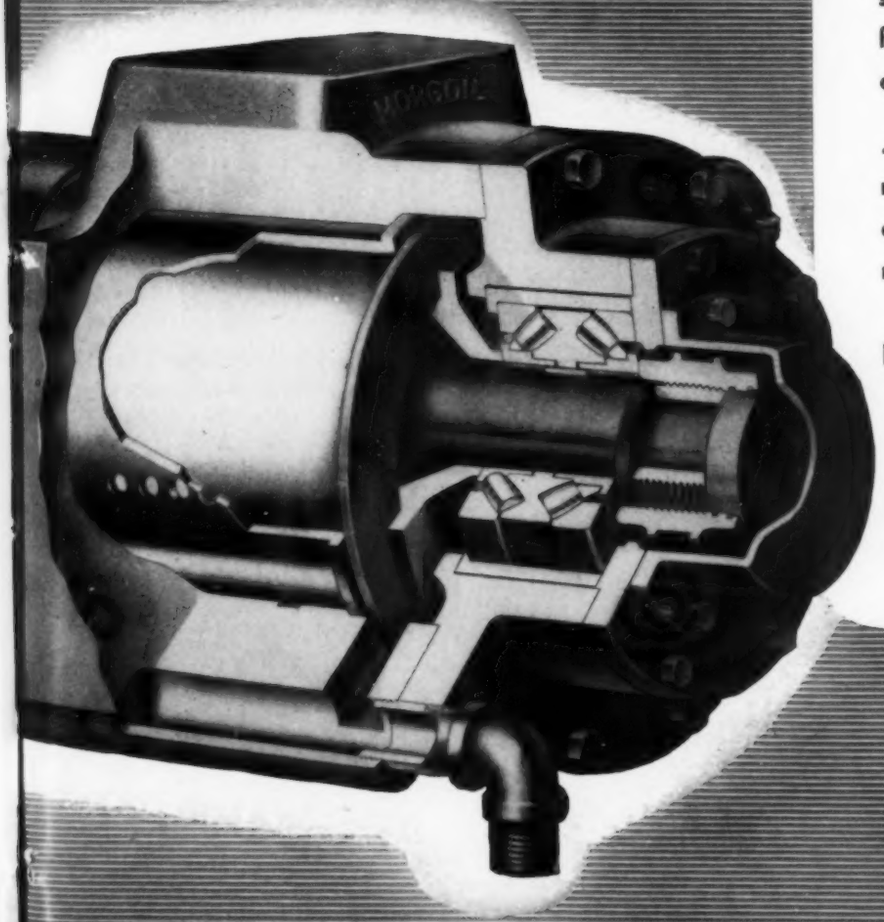
DETROIT · MILWAUKEE · LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.


International
Graphite Electrodes
FOR QUICK PICK-UP
. . . . . Many Times Faster!
. . . . Many Times Cheaper!
To speed-up handling of electrodes, International originated a new method of shipping them: Sizes up to 20" x 72" are bundled on pallets, bound with steel straps, can be loaded or unloaded in minutes by crane or fork lift. Users report unloadings in one-tenth usual time . . . . savings up to $200 per shipment.
Palletizing is but one of the ways International can help you cut overall electrode costs . . . . one of the reasons why International graphite electrodes help to lower costs.
IGE
ORIGINATORS OF PALLETIZED ELECTRODES
International Graphite & Electrode Corp.
ST. MARYS, PA.
4697

You can roll it THICK with MORGOILS





WANT to break down steel slabs or ingots . . . 2½" cold brass? Want a roll neck bearing that will take these tremendous shock loads day after day and come back for more? Want a bearing that is dependable and economical to operate?

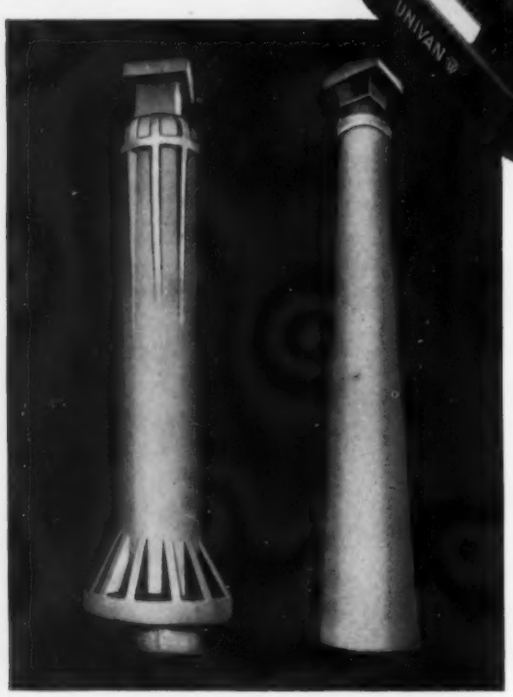
. . . Then you want MORGOIL. The only roll neck bearing built by rolling mill specialists and backed by 60 years of rolling mill experience.

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

Rolling Mills - Wire Mills - Gas Producer Machines - Regenerative Furnace Control

English Representative
INTERNATIONAL CONSTRUCTION CO.
56 KINGSWAY, WC2, LONDON, ENGLAND

MB-8



UNION *Alloy Steel* PEELS

Except for the charge itself, no piece of unprotected metal is subjected to greater heat for a longer time than the peel. And, hot or cold, it must withstand severe shock and stresses as well. "Union" has developed for this tough service peels of heat and shock resistant alloys in designs that add months to their useful life . . . Glad to quote from your specifications on either rough or fully machined castings.

Bridge that Gap with UNIVAN

DOUBLE LIFE HEAD CHARGING BOXES

It's a short haul from scrap yard to furnace . . . no warming-up time to ease the shock on chilled charging boxes before they're slammed into steel-melting temperatures.

No wonder so many ordinary boxes crack under this strain, and soon become scrap themselves. No wonder so many production-minded open hearth men have changed over to UNIVAN—the improved charging boxes of shock-resisting nickel-vanadium steel with reinforced Double Life Head! They've proved to their own satisfaction that a faster charging job can be done, for a longer time at less cost per year . . . Your request for further details and prices will receive our immediate attention.

"UNIVAN" Nickel-Vanadium Steel

UNION STEEL CASTINGS

DIVISION OF BLAW-KNOX CO., PITTSBURGH, PA.

Cinder Pots • Slag Pots • Coupling Boxes • Spindles • Gears • Bells and Hoppers • Ingot Cars • Charging Cars • Annealing Boxes and Bases

DURABLE • DEPENDABLE

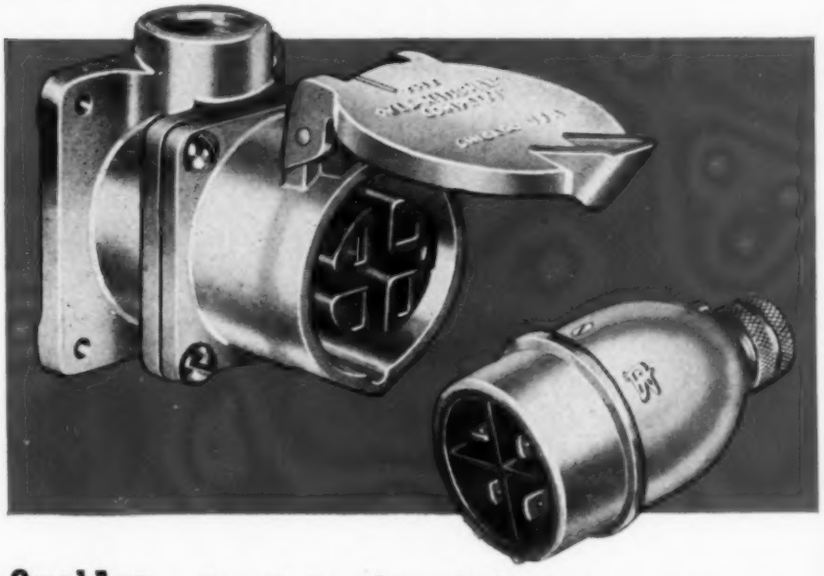
PYLE-NATIONAL

Heavy Duty Plugs and Receptacles

1, 2, 3, 4, 6, 8 pole interchangeable contact units

FOR PORTABLE ELECTRICAL EQUIPMENT

Pyle-National plugs and receptacles are built to withstand the most severe operating conditions, as proven by years of remarkably dependable service in a wide variety of industrial applications. The many substantial construction features of this extensive line of plugs and receptacles and the high quality of materials and workmanship insure safe operation, uninterrupted service and long life.



QuelArc • *Circuit Breaking Series* **Unique partitioned insulation provides long insulated paths through air and across surfaces for exceptional protection in these current rupturing devices. Galvanized cast metal housings, bakelite insulation and individually renewable contacts insure long service life. Ratings 20, 30, 60, 100 and 200 amperes, 250 volts DC, 600 volts AC—2, 3, and 4 pole—grounded through shell or extra pole. Threaded cap, plain and hinged spring door housing styles are available.**

Triploc *and Multiple-Circuit Series*

A line of exceptional versatility, unequalled in the heavy duty field, with a virtually unlimited number of assembly combinations for varied applications. Offers a selection of 1, 2, 3, 4, 6 and 8 pole contact units which are interchangeable and reversible in any single set of housings. Many types of single housings available of pressed steel with automatic lock and of cast metal threaded for watertight gasket seal. Multi-Circuit housings—2, 3 and 4 gang—available for combinations up to 32 poles. Ratings 15 and 20 amperes, 250 volts DC, 460 volts AC—circuit breaking. Pressed steel fusible and fuseless plugs measure 1 15/16″ outside diameter.

Midget Triploc *Series* **Same construction features as Triploc except for much smaller outside diameter of plug shell—only 1¼″. Interchangeable and reversible contact units—2, 3 and 4 pole—are of the flat blade type. Rated 10 amperes, 250 volts; 15 amperes, 125 volts.**

2-Gang Receptacle

Fusible Plug

Fuseless Plug

General Purpose *Series* **Available with cast metal housings in many types for circuit breaking and disconnect service. 30 amperes, 125 volts DC, 250 volt AC—1, 2, 3, 4, 5 and 6 pole. 60 amperes, 250 and 600 volts—3, 4 and 5 pole. 100 ampere, 250 and 600 volts—2, 3 and 4 pole. Also many special types, fusible and fuseless, for varied applications.**

THE PYLE-NATIONAL COMPANY

1370 NORTH KOSTNER AVENUE, CHICAGO 51, ILLINOIS

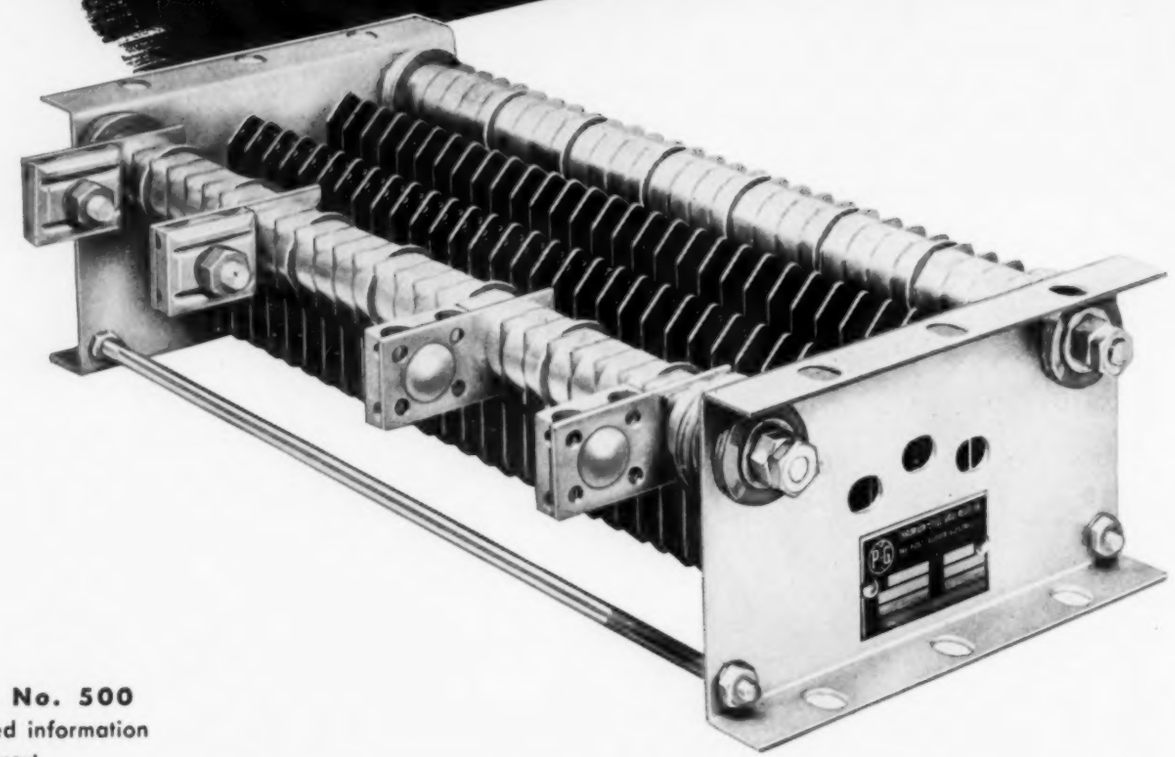
DISTRICT OFFICES and REPRESENTATIVES in Principal Cities of the United States

EXPORT DEPARTMENT: International Railway Supply Co., 30 Church St., New York • CANADIAN AGENT: The Holden Co., Ltd., Montreal

CONDUIT FITTINGS • FLOODLIGHTS • TURBO-GENERATORS • LOCOMOTIVE HEADLIGHTS • MULTI-VENT AIR DISTRIBUTION

P-G

Steel Grid Resistors HELP KEEP EQUIPMENT IN *Continuous* OPERATION



BULLETIN No. 500
Gives detailed information
Copy on request.

P-G nonbreakable steel construction and mica insulation, with provision for expansion enables P-G Steel Grid Resistors to withstand many factors responsible for resistor failure. By reducing failures and thus minimizing hours lost in electrical repair and maintenance, P-G Resistors will do their part to keep your production equipment in continuous operation.

P-G

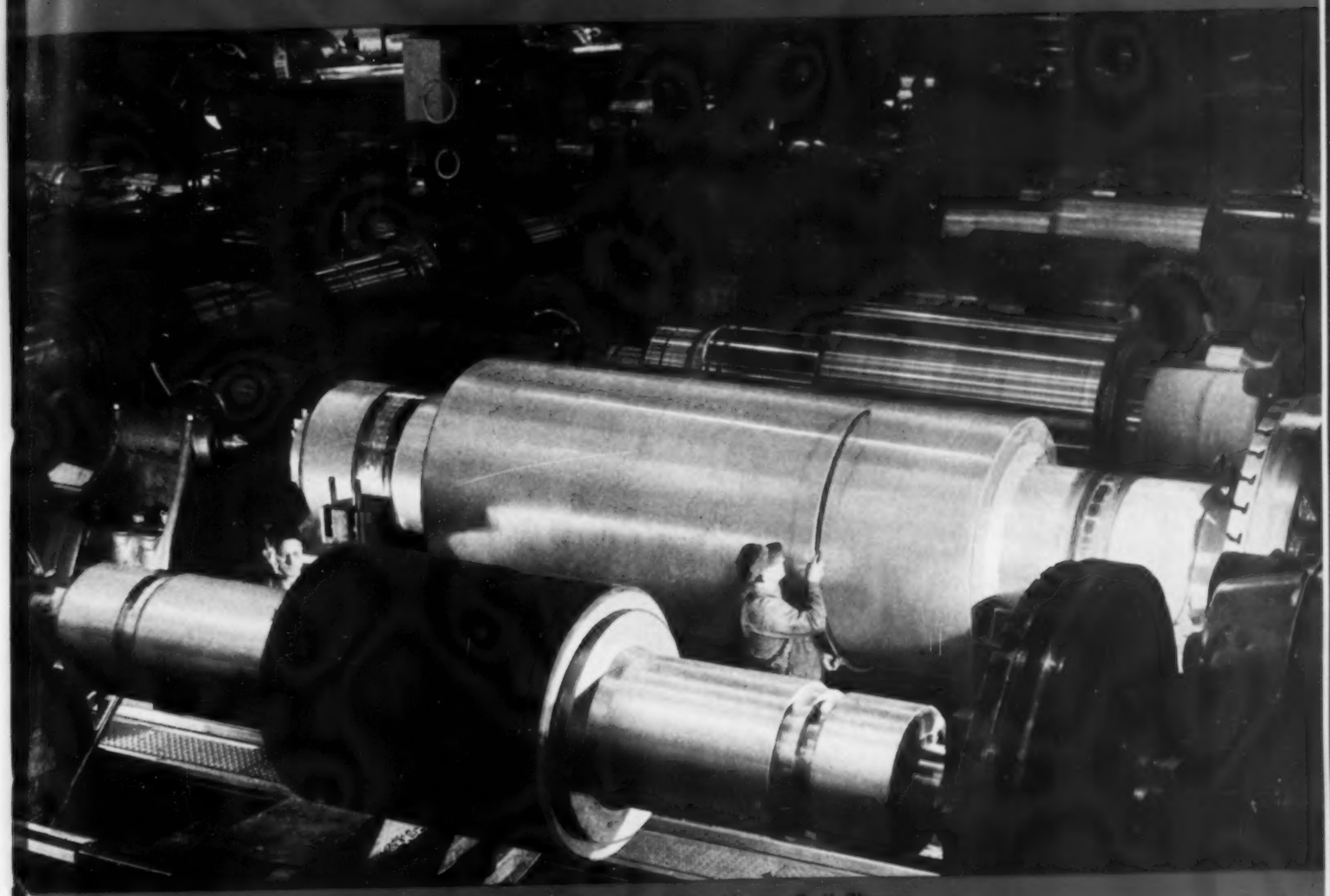
The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

MESTA ROLLS



A section in one of the Mesta Roll Shops

Mesta produces all sizes of iron and steel rolls including the largest used in industry today. Efficient plant equipment, skilled workmen with long service records, an engineering staff whose technical ability has been accumulated over many years—these resources are responsible for Mesta's leadership in the production of the finest in rolls and other rolling mill equipment.

DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

MESTA MACHINE COMPANY · PITTSBURGH, PA.

Foundry cuts annealing and firing time practically in two!

How Johns-Manville Insulating Fire Brick enables 6 new furnaces to do work formerly requiring 12

This is the story of a foundry that called on Johns-Manville Insulation Engineers about the plans for their new annealing furnaces.

The company had been operating 12 furnaces constructed with heavy fire brick. One of these furnaces was rebuilt, for test purposes, with insulating materials recommended for the job by Johns-Manville Insulation Engineers. After the furnace was completed, exhaustive operating tests were made and results were compared with the old furnaces.

Test Results

The old furnaces in this foundry performed with an average annealing cycle of 120 hours. The new furnace made it possible to cut the annealing cycle to as low as 72 hours.

Partially completed furnace with J-M materials ready for installation.

The firing time was 80-100 hours depending upon the quality of fuel available. Average firing time in the new furnace was cut to 40 hours.

These results were so striking that the management decided to build 5 additional furnaces of similar construction.

The 6 new furnaces, as engineered by Johns-Manville, are expected to fill all production needs of the plant—replacing entirely the 12 old-style furnaces—resulting in doubled operating efficiency.

Materials Used

The furnace walls were built with thirteen and a half inches of JM-23 Insulating Fire Brick. In every fifth course, vertically, a header row of brick was used with a stretcher course of brick to tie the wall into a solid unit.

To further decrease the heat transfer through the walls, a combination of 2″ thickness of J-M Superex Blocks and 1″ thickness of 85% Magnesia Blocks was used between the insulating brick walls and the outer steel casing.

The arch was constructed with a 9″ thickness of JM-26 Insulating Fire Brick. Over this, 5 inches of Sil-O-Cel Natural Brick was installed in two 2½″ layers. That part of the arch subject to abrasion from the powdered fuel is constructed of fire brick. In order to keep the heat transfer approximately uniform over the entire arch area, that portion constructed of fire brick was backed with a 2½″ thickness of J-M Superex Blocks. And, over this, five inches of Sil-O-Cel Natural Brick was applied.

Cutting J-M Insulating Fire Brick on the job.

J-M 1626 cement was used as bonding agent.

The furnace bottom was insulated first with a 4″ thickness of Sil-O-Cel C-3 concrete. Over this base, ten inches of Sil-O-Cel C-22 brick were laid. A 4″ course of paving brick supplies the wearing surface for the high load-bearing insulating material used for the furnace bottom.

Engineering Service

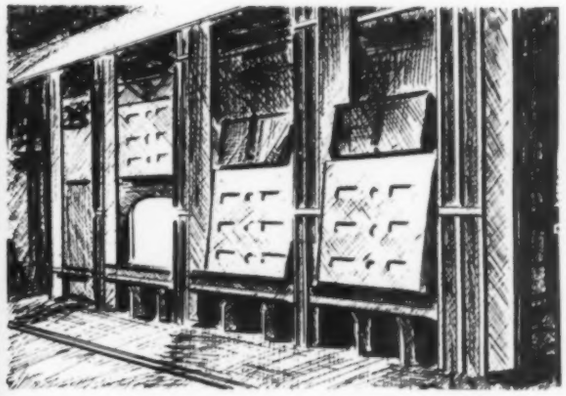
The same service performed by J-M Insulation Engineers in selecting the right combination of insulating materials to increase efficiency for this plant can be made available to you. Write Johns-Manville, Box 290, New York 16, New York.

JOHNS-MANVILLE JM PRODUCTS

For Complete Fulfillment of Open Hearth Needs Call on

F.E.I.

WHATEVER your open hearth requirements . . . whether it's a complete job of design, construction and installation of a new furnace . . . or the rebuilding of an existing furnace . . . F.E.I. has the men, the experience and the know-how to do the job as you want it done. You are invited to consult with us with no obligation to you.

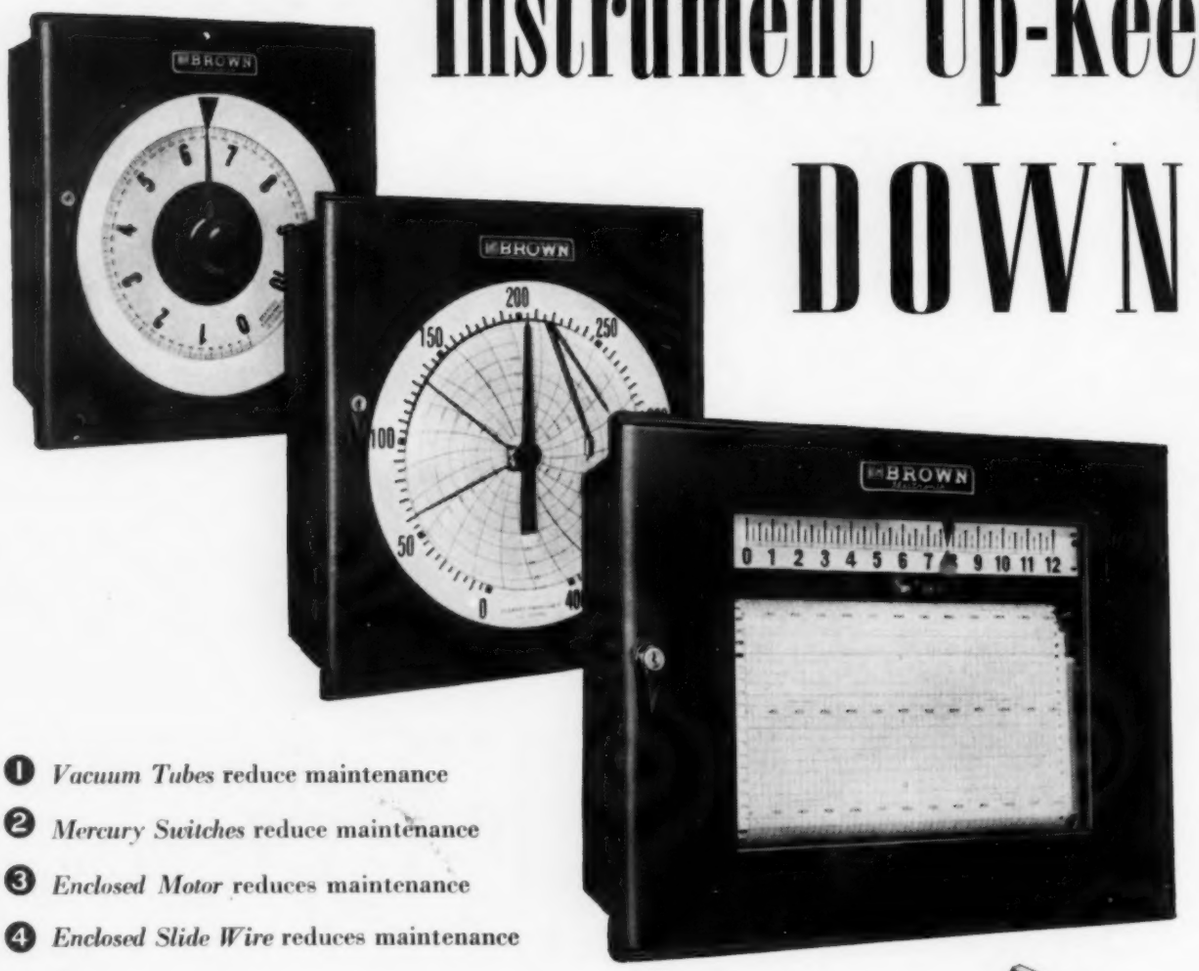


F.E.I. ALSO BUILDS: Open Hearth Furnaces; Soaking Pits; Continuous Bloom, Billet and Slab Heating Furnaces; Direct Fired Cover Furnaces for sheet and coil annealing; Salt Descaling Furnaces for stainless steel sheet, bar and other products; Heat Treating Furnaces for every use; Galvanizing Furnaces for tubes, sheet and metalware.

FURNACE ENGINEERS, INC.

1552 WEST LIBERTY AVENUE, PITTSBURGH, PA.

Built to Keep Instrument Up-Keep DOWN



1. *Vacuum Tubes* reduce maintenance
2. *Mercury Switches* reduce maintenance
3. *Enclosed Motor* reduces maintenance
4. *Enclosed Slide Wire* reduces maintenance

YES, *ElectroniK* POTENTIOMETERS ARE RUGGED!

Yet with all this, ElectroniK Potentiometers possess greater accuracy, sensitivity and speed of response. Try them and you'll see . . . they have been acclaimed for outstanding performance for eight years in all industries.

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4464 Wayne Ave., Philadelphia 44, Pa.
Offices in principal cities of the United States, Canada and throughout the world

ElectroniK Potentiometers . . . strip chart, circular scale and circular chart . . . are fully explained and described in Catalog 15-13. A copy will be sent to you upon request . . . write today!

BROWN *Advanced Instrumentation* FOR METAL WORKING
Product of MINNEAPOLIS Honeywell

CAPACITY LOSSES— THEIR CAUSES AND CORRECTION---

This picture shows actual condition of a 24" main before cleaning. Note the condition of the deposit, not only the thickness but particularly the rough and porous surface. These are only some of the many factors that contribute to capacity losses.

C Value before cleaning 69
GPD before cleaning 5.6 MGD

Note after cleaning and lining by Pittsburgh Eric Process the smooth, clean interior of the pipe which does not hinder the flow of the water and restores the pipe to its original capacity.

C Value after cleaning 130 (average of tests)
GPD after cleaning 10.6 MGD

Whatever problems you have — Industrial — Municipal — Plant — Railroad — Maintenance — Supply — Engineering!!! If they pertain to water supply or sewage disposal a Pittsburgh Pipe Cleaner Company engineer can solve them. Our complete comprehensive rehabilitation program and engineering service is THE ANSWER. Write today for full details.

PITTSBURGH PIPE CLEANER COMPANY

133 Dahlem St., Pittsburgh 6, Pa.

BALTIMORE • BIRMINGHAM • BOSTON • BRADENTON, FLORIDA • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI
DETROIT • HOUSTON • NEW YORK • PHILADELPHIA • ST. LOUIS • WASHINGTON

Large Consulting Engineering Company

Selects EC&M Valimitor Starters

For Application Having Short Circuit Capability of 300,000 KVA

THE SELLER BY ACCEPTING THIS ORDER, AGREES TO THE SEVERAL CONDITIONS PRINTED ON THE REVERSE SIDE HEREOF, AND MUST SIGN AND RETURN AT ONCE TO [redacted] THE ACCEPTANCE COPY OF THIS ORDER.

Furnish the following:

Item	Quantity	Description	Net Unit Price	Net Item Price
1	1	Metal enclosed assembly with five full voltage starters for control of the following five 2,300 v induction motors: 1 - 300 hp boiler feed pump motor 1 - 350 hp induced draft fan motor 1 - 100 hp forced draft fan motor 2 - 125 hp coal pulverizer motors		[redacted]

The above motor starters shall be in accordance with attached specification.

The power circuit which will supply this assembly has a short circuit capability of 300,000 kva at 2,300 volts, and the units shall be suitable for operation under these conditions.

Proof of acceptance of EC&M VALIMITOR Motor Starters is shown by the above order issued by the consulting engineering firm handling a new power plant extension.

EC&M VALIMITOR Starters cost about the same as standard starters equipped with auxiliary protective devices having only limited interrupting capacity... but the VALIMITOR Starter gives *unlimited* protection. There is *no ceiling* on VALIMITOR protection... the design of EC&M VALIMITOR Starters is based on safely interrupting a faulted motor circuit even if supplied from a bus of infinite KVA. And there's nothing to replace after a fault — just press the "start" button to re-start.

Be safe with EC&M VALIMITOR Starters for 2300-4600 volt motor drives. No need to worry about the starter you select today being outmoded by an increase in available KVA tomorrow. To secure *unlimited* protection at one cost, simply send us the name-plate data of your motors. EC&M VALIMITOR Starters give permament, all-time protection.

ONLY EC&M VALIMITOR STARTERS GIVE ALL THESE FEATURES--

1. SHORT CIRCUIT Protection— regardless of available KVA.
2. OVERLOAD Protection.
3. LOW VOLTAGE Protection.
4. CUSHIONED STARTING — gives a smoother start and lower inrush current — improving starting conditions — may save cost of more expensive reduced voltage starter.
5. NO REPLACEMENTS to restart, after a fault.

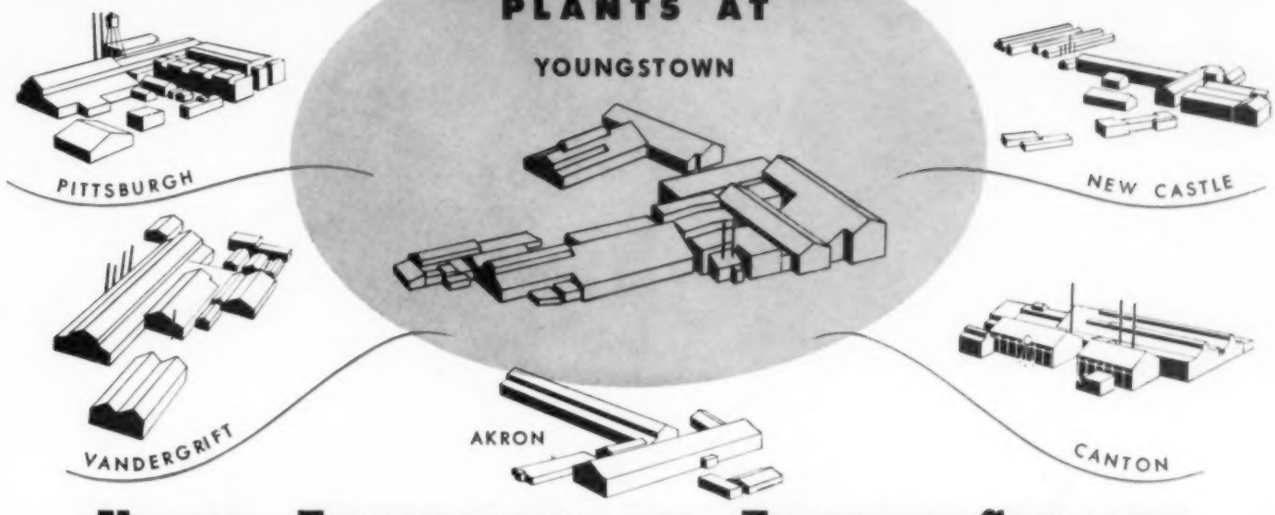
MAXIMUM RATINGS		
Squirrel-cage, Synchronous or Wound-rotor Motors.		
2300 volts		4600 volts
600 HP	60 cycles	600 HP
300 HP	25 cycles	250 HP

For Complete Coverage At All Times... Switch to EC&M Valimitor Motor Starters

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79TH STREET • CLEVELAND 4, OHIO

Erection Floor, New Castle Plant



UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at: PITTSBURGH · VANDERGRIFT · NEW CASTLE · YOUNGSTOWN · CANTON · AKRON

Subsidiary: Adamson United Company, Akron, Ohio

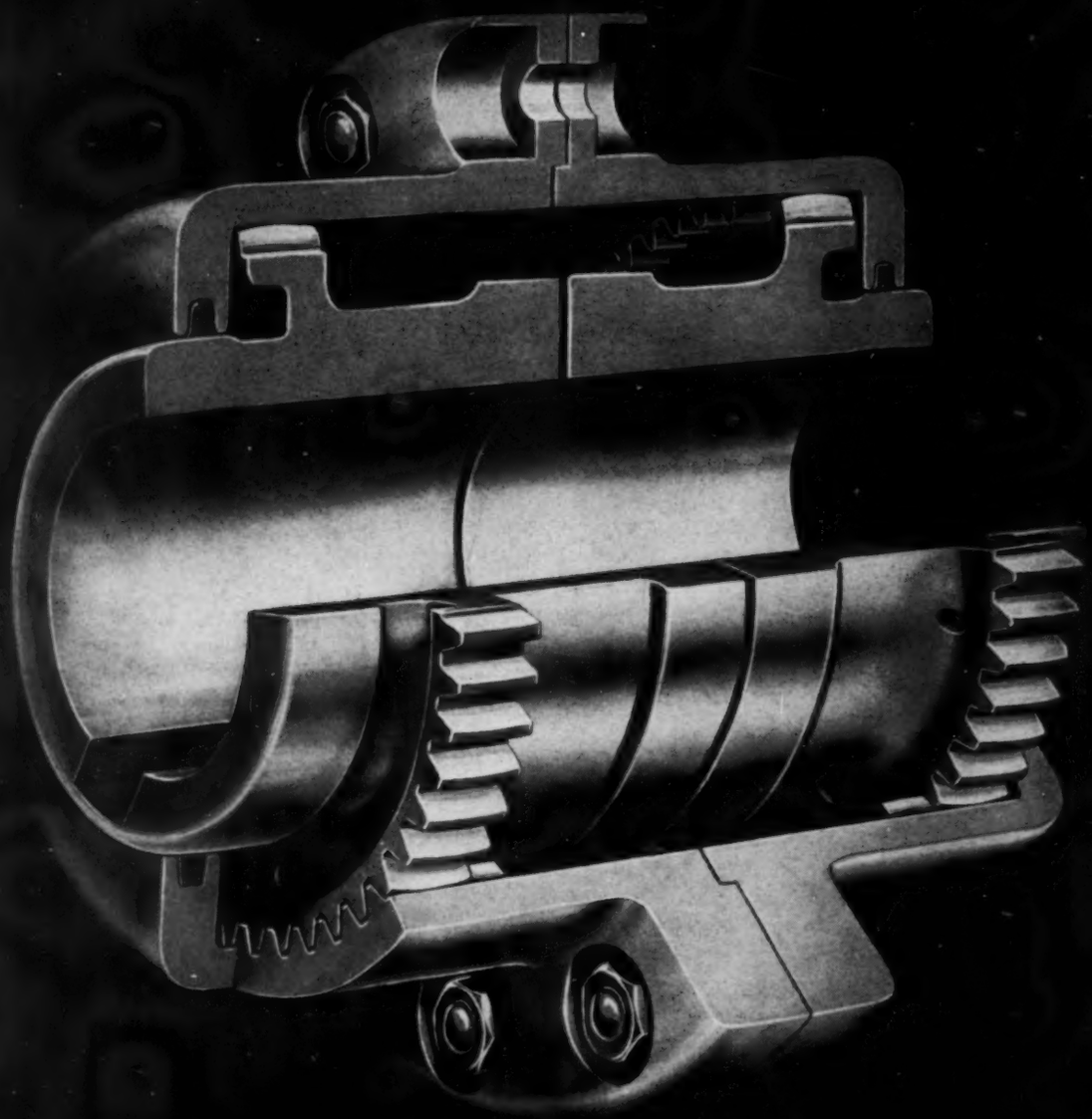
Affiliates: Davy and United Engineering Company, Ltd., Sheffield, England

Dominion Engineering Works, Ltd., Montreal, P.Q. Canada

S. E. C. I. M. Paris, France

Designers and Makers of Rolls and Rolling Mill Equipment

POOLE



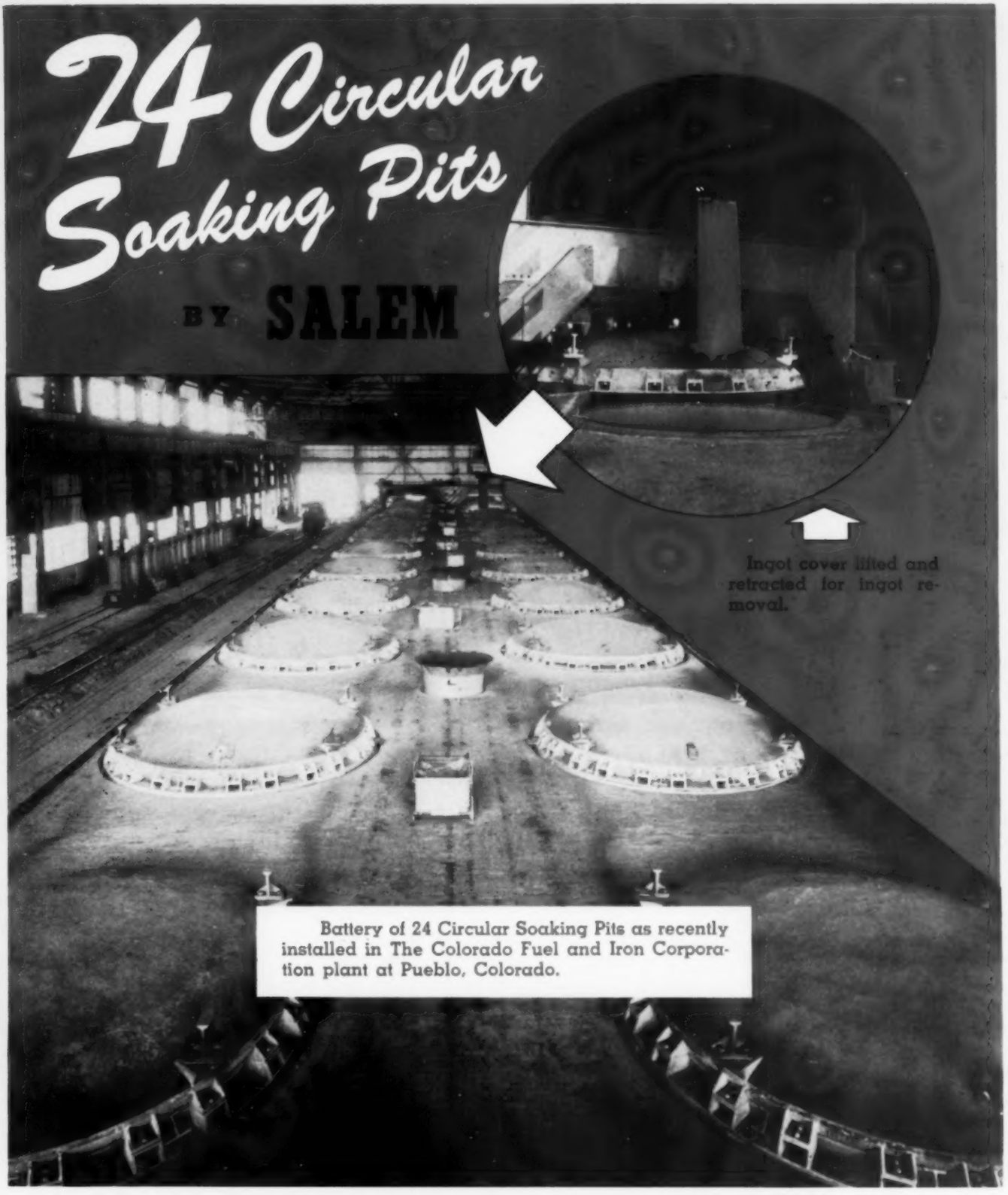
A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

24 Circular Soaking Pits BY SALEM



Ingot cover lifted and retracted for ingot removal.

Battery of 24 Circular Soaking Pits as recently installed in The Colorado Fuel and Iron Corporation plant at Pueblo, Colorado.

Every Salem office has the facts! Address nearest city listed below

P-7

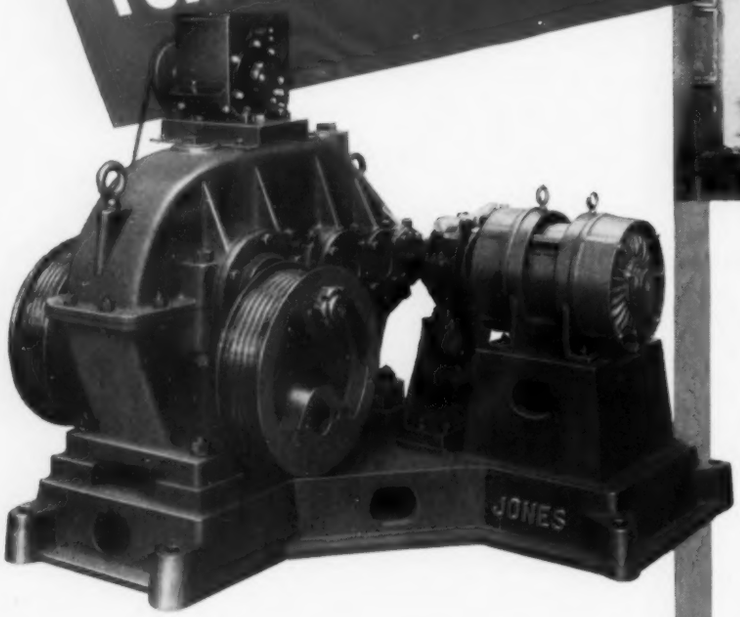
Salem Engineering Company

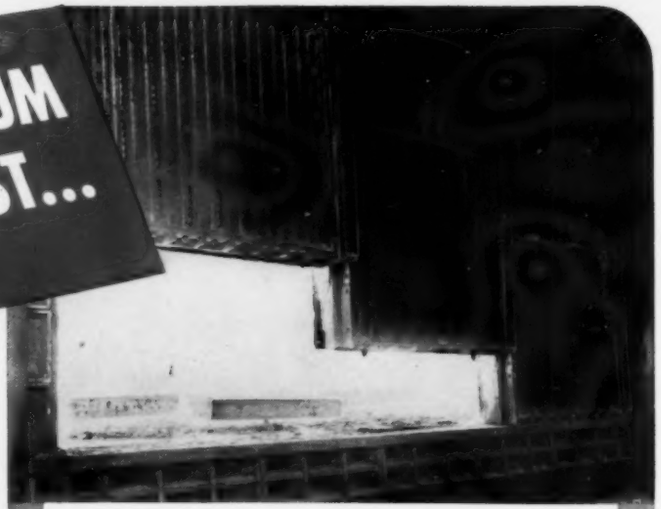
HEADQUARTERS FOR HEAT TREATING DESIGN

Salem, Ohio *Southwest Office, Fort Worth, Texas*

Salem Engineering (Canada) Ltd., Toronto, Ont. · Salem Engineering Company, Ltd., Sheffield, England

JONES ECCENTRIC DRUM FURNACE DOOR HOIST...





JONES ECCENTRIC DRUM FURNACE DOOR HOIST showing the two eccentric winding drums mounted on opposite ends of the slow speed shaft. Opening and closing take place on the short radius of the eccentric so minimum motor torque is required for starting. Furthermore there is practically zero impact when the door starts to open and when finally closing, as a protection to the refractory material. Electric brake is located between the motor and hoist and the limit switch is located on top of hoist. Speed reduction is through the Jones triple herringbone reducer unit.

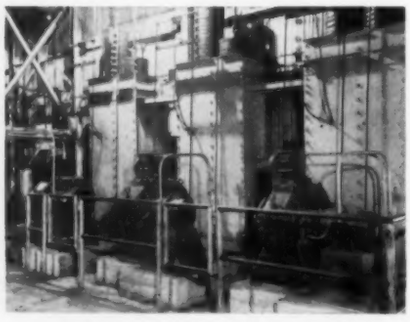
THE JONES ECCENTRIC DRUM FURNACE DOOR HOIST shown in the accompanying illustrations, was developed to handle the doors on **FRAZIER-SIMPLEX, INC.** "All-Door" Plate Mill Furnaces. Since each furnace, of the installation illustrated here, has six consecutive doors and no front wall and each door weighs 8500 lbs. (counter weighted about 6600 lbs.), it can easily be appreciated that the door hoists came in for the most careful engineering study. Three consecutive doors on each side of the divided furnace, provide an opening 21 ft. long in each furnace.

THE JONES ECCENTRIC DRUM TYPE HOISTS, developed to solve this door opening problem, have now been in operation several years and have provided the excellent service that has come to be taken for granted by the users of Jones transmission products.

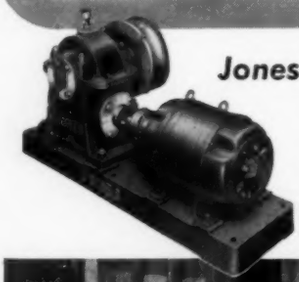
Door hoists of this, and other types, are built by Jones as complete units with motor included, if desired, or with a base to take standard motor as supplied by purchaser.

If you have a door handling problem, the Jones engineering department will be pleased to make a recommendation covering a unit for it.

W. A. JONES FOUNDRY & MACHINE CO.
4431 Roosevelt Rd., Chicago 24, Ill.

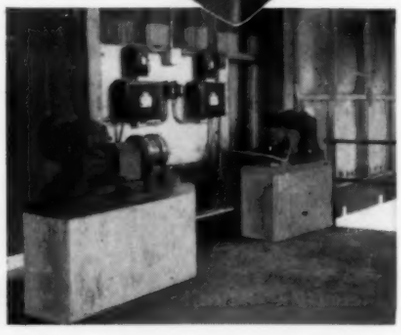


Rear view of the furnace showing three of the six Jones eccentric drum type furnace hoists and the door counter weights.



Jones "Slipper type" Hoists for small furnace or mill building doors.

This Jones door hoist is built in several ratings and in almost any convenient arrangement of sheaves and cables. No limit switches of any kind are required with this unit. A bronze ring on the winding drum slips to take care of overwinding.



The two Jones door hoists shown at the left are installed for opening and closing mill building doors.

Since 1890

Jones

In the Service of Industry

HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS

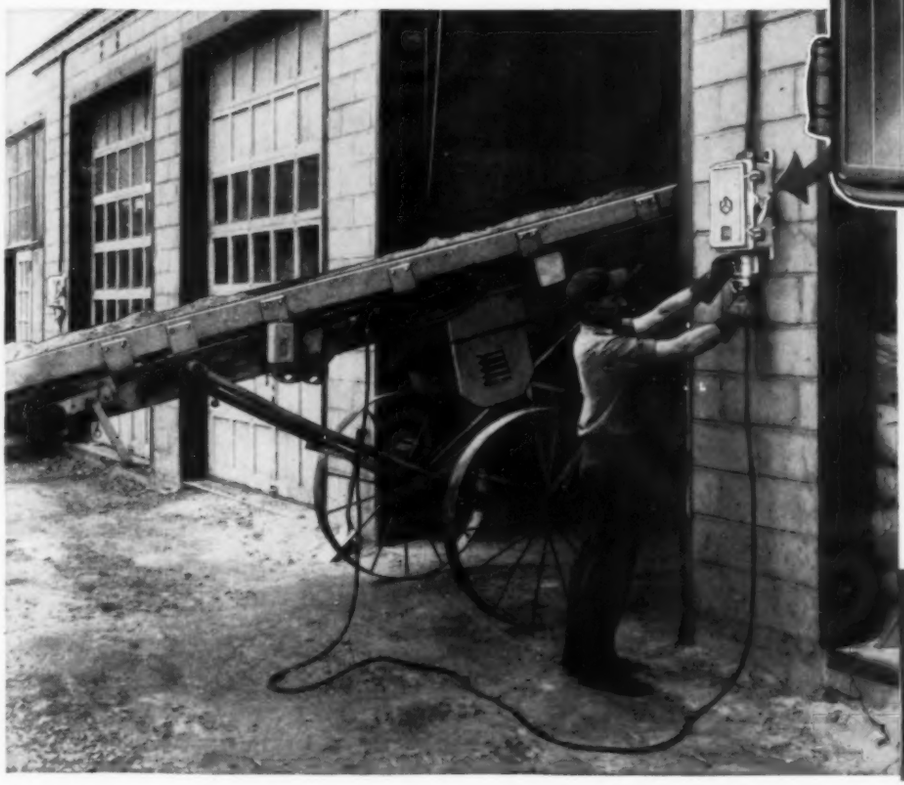
PULLEYS • GEARS • V-BELT SHEAVES • ANTI-FRICTION

PILLOW BLOCKS • FRICTION CLUTCHES • FLEXIBLE COUPLINGS

Type WMKS **Interlocking** Safety Switch and Plug Receptacle

CONDULET*

for the control of all kinds of
portable electrical equipment
in both indoor and outdoor locations



Type WMKS Interlocking Safety Switch and Receptacle Conduiet with Type DP Interlocking Plug

It's heavy duty!
It's raintight!

Safety. Positive interlock prevents opening the case or withdrawing the plug unless the switch is "off". Switch can't be turned "on" unless the case is closed and the plug fully inserted.

Switches. Motor circuit switch. Quick make and break. Double break, reinforced, positive pressure-type blade and jaw construction. Positive pressure fuse clips. Combination solder or solderless wire lugs. 2 or 3-pole fusible.

Plug Receptacles. Style 1 is grounded through the shell of the plug and the receptacle housing. It will take the plugs used with the former Type MKS of the same rating. Style 2 is grounded through an extra pole and the shell. An eyebolt and wingnut prevents accidental withdrawal of the plug when the switch is open.

Cast metal case. Strong and durable. Four sturdy mounting feet. Many possible threaded hub arrangements for both vertical and horizontal conduit. Cover may be padlocked to prevent unauthorized entry. Operating handle may be padlocked "on" or "off".

Threaded operating shaft. Bearings permanently lubricated to resist corrosion and prevent the entrance of dust and moisture.

Horse-power ratings. 2 through 50 H. P. 30, 60, 100 or 200-ampere. 230 or 575-volt A. C.

Listed in Condulet Catalog 2500, Section 50.

*CONDULET is a coined word registered in the U. S. Patent Office. It designates a product made only by the Crouse-Hinds Company.

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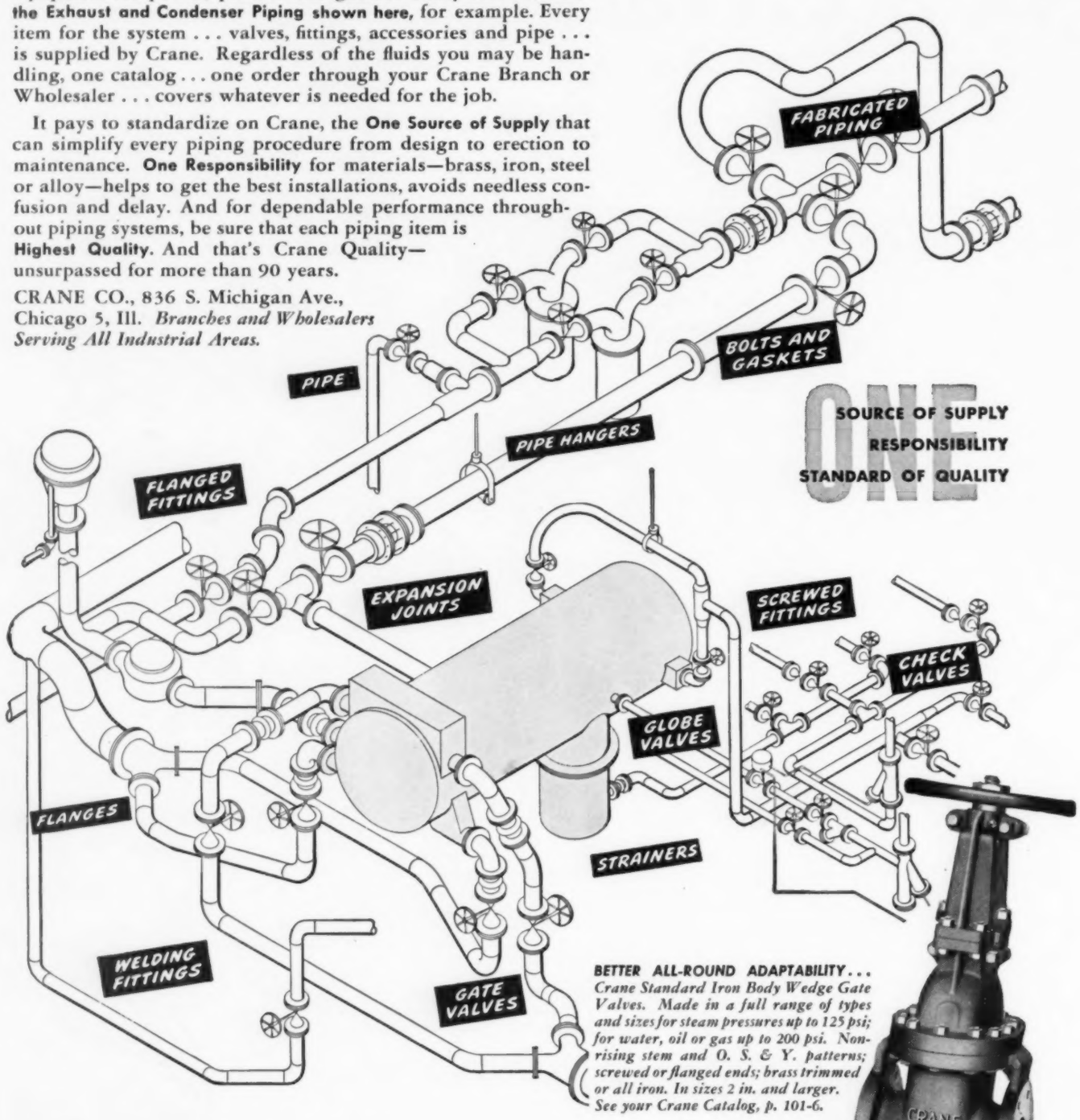
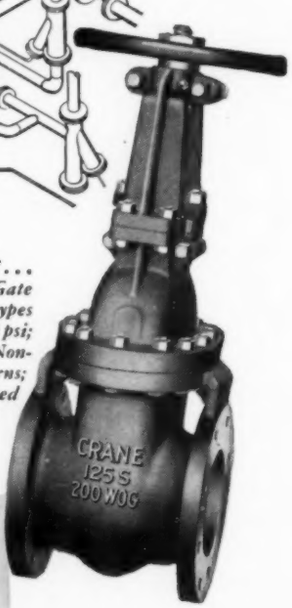
Complete Piping Materials Service ... from one complete line

That's the Crane line—the world's most complete source of piping equipment for power, process and general utility services. **Take the Exhaust and Condenser Piping shown here,** for example. Every item for the system . . . valves, fittings, accessories and pipe . . . is supplied by Crane. Regardless of the fluids you may be handling, one catalog . . . one order through your Crane Branch or Wholesaler . . . covers whatever is needed for the job.

It pays to standardize on Crane, the **One Source of Supply** that can simplify every piping procedure from design to erection to maintenance. **One Responsibility** for materials—brass, iron, steel or alloy—helps to get the best installations, avoids needless confusion and delay. And for dependable performance throughout piping systems, be sure that each piping item is **Highest Quality.** And that's Crane Quality—unsurpassed for more than 90 years.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*





BETTER ALL-ROUND ADAPTABILITY . . . *Crane Standard Iron Body Wedge Gate Valves. Made in a full range of types and sizes for steam pressures up to 125 psi; for water, oil or gas up to 200 psi. Non-rising stem and O. S. & Y. patterns; screwed or flanged ends; brass trimmed or all iron. In sizes 2 in. and larger. See your Crane Catalog, p. 101-6.*

EVERYTHING FROM . . .

VALVES · FITTINGS
PIPE · PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

Johnston Corrugated Cinder Pot Performance Key to Slag Handling Economy

View showing Johnston Corrugated Cinder Pots at slag dump, Weirton District

Close-up of Johnston Corrugated Cinder Pot

Continuous Developments Increase Service Life of Johnston Corrugated Cinder Pots

Slag Handling is expensive business—part of the cost of every ton of steel. But when you apply Johnston Corrugated Cinder Pots and Slag Handling Equipment you'll find their performance an important factor in keeping slag disposal at the lowest cost-per-ton of steel produced.

Every Johnston Corrugated Cinder Pot is engineered for its specific job. That's why they establish records for heat-hours of service life—why they are so economical for use in blast furnace or open hearth slag disposal operations.

Then, too, you'll find that our engineers are constantly developing and improving methods and equipment for more efficient slag handling. This continuing research is reflected in reduced slag disposal costs when you adopt Johnston Corrugated Cinder Pots and Slag Handling Equipment.

Tapping a 480 ton open hearth heat in two 250 ton ladles, the slag being handled by two 400 cubic foot Johnston Corrugated Cinder Pots

Don't forget that it pays to *keep your eye on what's new at Mack-Hemp.* Just write or phone and we'll show you how we can expedite your slag handling by installing this modern equipment.

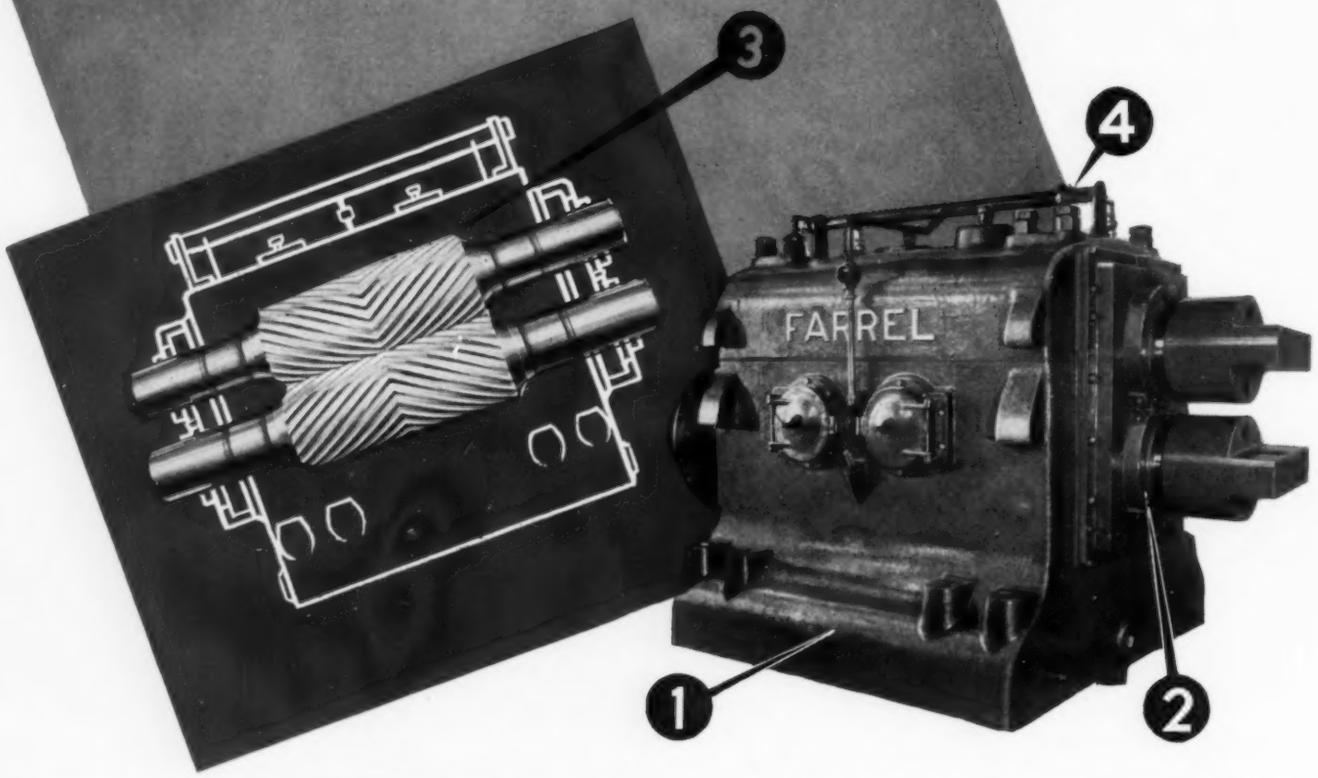
MACKINTOSH-HEMPHILL CO.

PITTSBURGH AND MIDLAND, PA.

HOW DOES FARREL

ENGINEER STAMINA

into a PINION STAND?



Stamina in a Farrel pinion stand is its ability to maintain continuous high efficiency of power transmission, despite the shocks and stresses incurred during many years of rugged duty.

Farrel design gives a pinion stand this enduring efficiency by providing special protection at every vital point. These engineered-in safeguards "shockproof" the pinion stand, fortify against wear, and assure long, trouble-free service:

1. HOUSING—Meehanite, cast steel or welded steel construction, designed to bear the brunt of continued strain and stress encountered in rolling mill service and to maintain accurate alignment of the pinions.
2. BEARINGS—Babbitt-lined, steel-backed, sleeve bearings, or any approved make of anti-friction bearings—always amply proportioned for the job they have to do.
3. PINIONS—Continuous tooth herringbone, precision generated by the famous Farrel-Sykes process. The fact that the helices meet in sharp apices, instead of being separated by a center groove, provides extra strength and load-carrying capacity. Interlacing of the teeth, gradual engagement and inclined line of pressure all contribute to smooth, quiet operation and maintenance of correct tooth action throughout the life of the pinions.
4. LUBRICATION—By dip-and-splash system, or force-feed by separate motor-driven pump or from centralized lubricating system, depending on conditions or requirements.

Farrel will design and build a pinion stand to fit your particular application. Information and specifications on request.

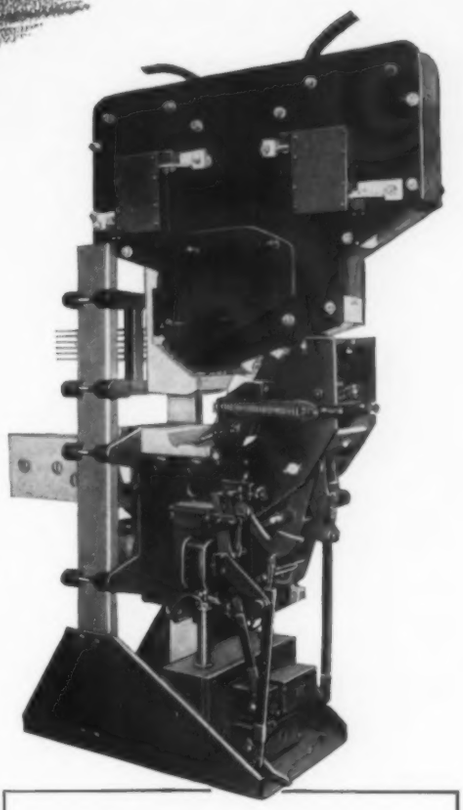
FB-274

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.

Plants: Ansonia and Derby, Connecticut; Buffalo, New York

Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Chicago, Los Angeles, Tulsa, Houston

Farrel-Birmingham



Electrical disturbances can't spread trouble with this *more dependable, better built* breaker on the job!

● Short circuits and extremely heavy overcurrents don't have a chance to ruin your essential generators, motors, rectifiers, and connected production equipment—when your electrical distribution system is protected by proper application of I-T-E Type MT Automatic Reclosing Circuit Breakers.

The MT was specially developed by I-T-E—*Switchgear Specialists*—for interrupting extremely heavy direct currents. It breaks a circuit in .028 seconds (about 1¾ cycles on a 60 cycle basis) at 25% to 100% of interrupting capacity. I-T-E's *Rate-of-Current-Rise* Trip anticipates extremely heavy currents—distinguishes between a useful load of high value and a dangerous fault current—and trips the breaker before the danger peak is reached. Shorts and overcurrents are cleared instantly, dependably, before they have a chance to cost you money.

And with the MT breaker, you get an exclusive I-T-E "extra" —*better design* to give you the benefits of manufacturing savings which, in turn, allow higher-quality refinements *at no extra cost*.

Complete details on the I-T-E Type MT Air Circuit Breaker (including Automatic Reclosing Applications) are contained in illustrated catalog 2202. Send for your copy.

TYPE MT — for pedestal mounting. Single pole, electrically operated. Application: 250 and 750 Volts. Interrupting rating is 150,000 Amp. in continuous ratings 2000 and 4000; 250,000 Amp. in continuous ratings 6000 and above.

ARC EXTINCTION IN THE MT AIR BREAKER

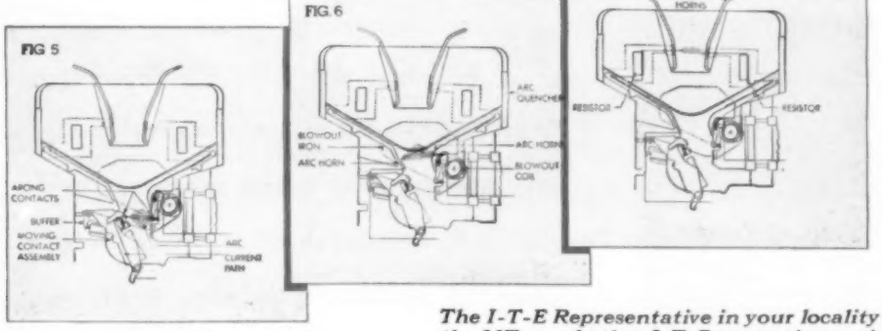


FIG. 5 First stage in circuit interruption: Arc drawn between arcing contacts; blow-out coil in circuit.

FIG. 6 Second stage: Arc transferred to arc horns.

FIG. 7 Final stage: Arc transferred to secondary arc horns; resistors in circuit.

The I-T-E Representative in your locality will be glad to advise you on applying the MT—and other I-T-E protective equipment—to your electrical distribution system. Use his services without obligation.

I-T-E R&IE *

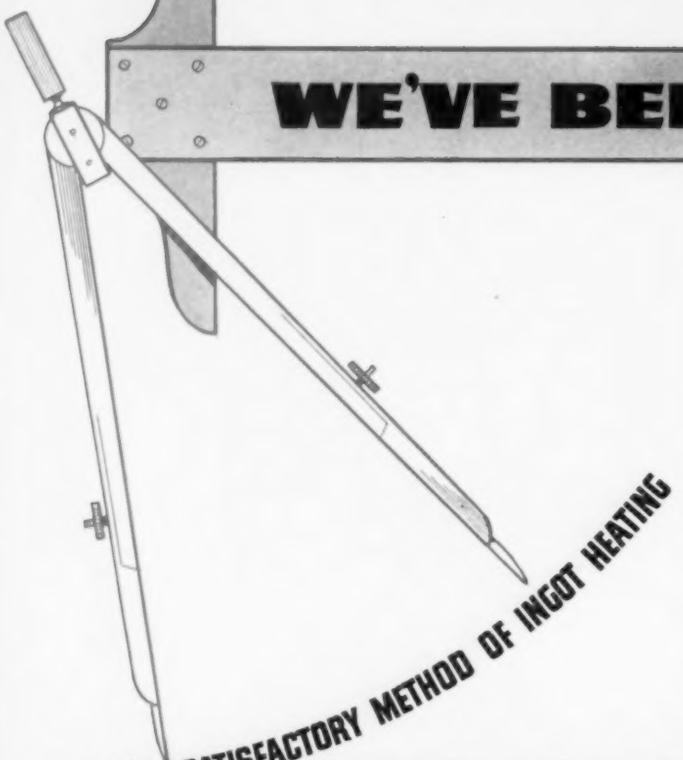
MILL TYPE SWITCHGEAR

The Leader In Technical Excellence

I-T-E CIRCUIT BREAKER CO., 19th & HAMILTON STS., PHILA. 30, PA. — 31 OFFICES IN THE UNITED STATES
In Canada, EASTERN POWER DEVICES, Ltd., TORONTO

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS • HIGH SPEED CIRCUIT BREAKERS
*FOR POWER SWITCHING EQUIPMENT, REFER TO RAILWAY AND INDUSTRIAL ENGINEERING CO., AN I-T-E SUBSIDIARY

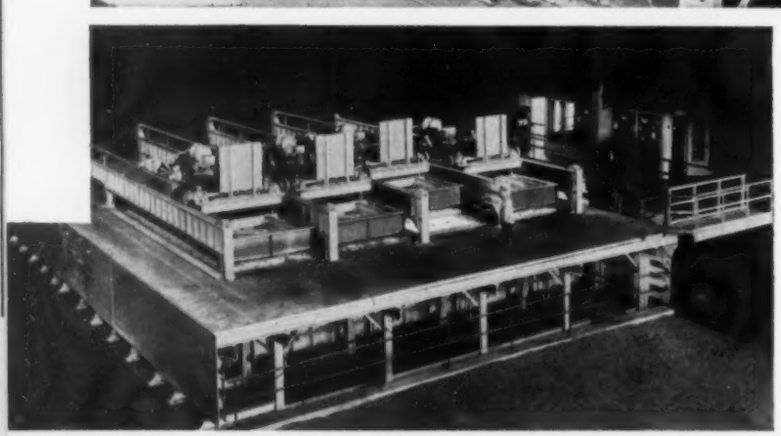
WE'VE BEEN ENGINEERING



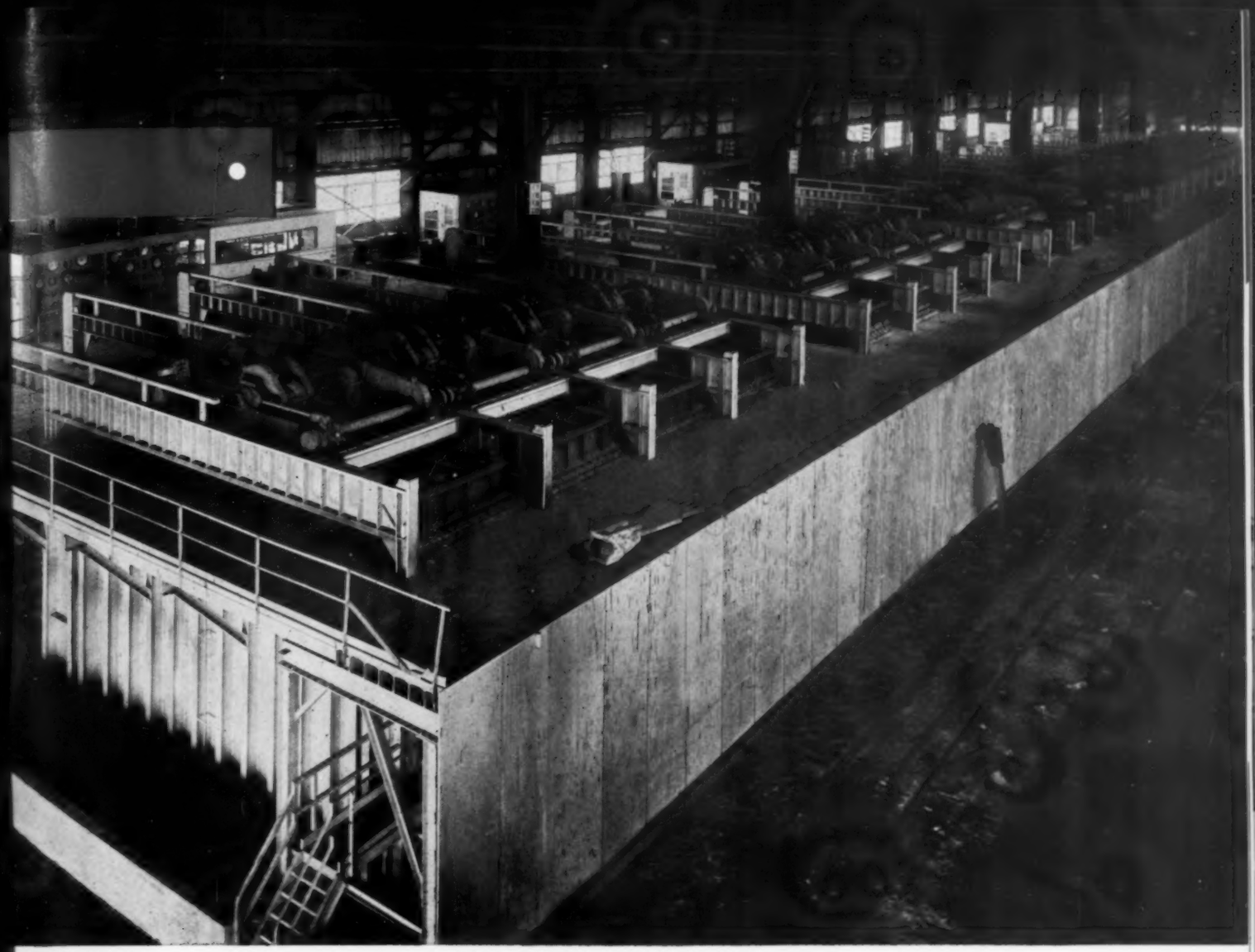
THE MOST SATISFACTORY METHOD OF INGOT HEATING

'SURFACE' ONE-WAY FIRED PITS

* FOR 23 YEARS!



* Ever since the first 'Surface' One-Way Fired Soaking Pit was installed in 1926, our engineers have been working with steel men in a program of continuous development of heating equipment to meet the prevailing metal production need.



Today, Surface One-Way Fired Soaking Pits incorporate the most modern features in design and operation to make possible high quality as well as quantity tonnage.

During the 23-years of 'Surface' Pit engineering the One-Way Firing principle has remained the most satisfactory method of ingot heating. It is convincing to see 'Surface' Pits in operation.

Furthermore, 234 One-Way Fired Pit installations have been made since 1936...155 since 1942...indicative of an industry trend to proved heating methods and equipment. These installations are to be found in the plants of 21 leading steel companies, and there are as many as 64 pits representing 11 repeat orders in 22-years, at one company alone.

These outstanding advantages are offered in 'Surface' One-Way Fired Pits: Simplest Construction; Greater Capacity; Most Efficient Firing; Best Heat Distribution, Lowest Maintenance. *Ask a 'Surface' Sales Engineer for details.*

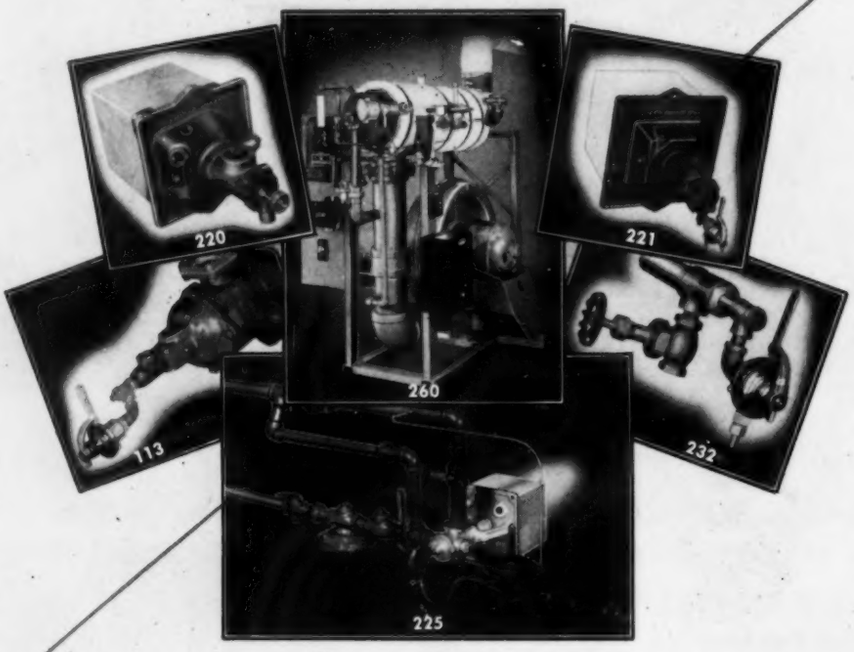
SURFACE COMBUSTION CORPORATION, TOLEDO 1, OHIO

'Surface' ONE-WAY FIRED SOAKING PITS

Peak Efficiency either *Gas or Oil* *with*

North American

Dual-Fuel Burners*



THE LINE IS *Complete*.....SELECT

THE BURNER YOUR OPERATING CONDITIONS REQUIRE

113—Long Flames. **220-221**—Short Flames, sealed-in mountings. **225**—For rugged duty, open or closed mounting, gas at zero. **232**—Compressed air atomizing oil inserts. **260**—Oiltogas Converter for burning oil as a gas in existing gas burners.

* Dual-Fuel: The North American name for burners designed especially for both gas and oil. Fuel changed by merely turning valves.

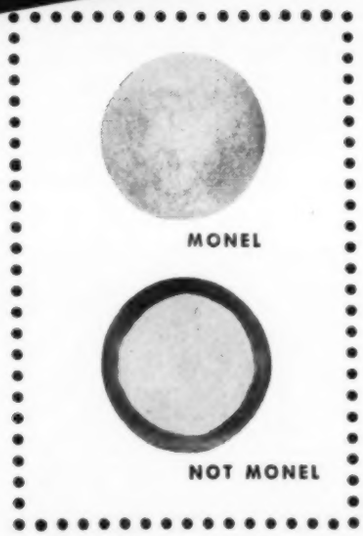
THE NORTH AMERICAN MANUFACTURING COMPANY

MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT FOR GAS OR OIL

BRANCH OFFICES with FIELD ENGINEERS in PRINCIPAL CITIES

CLEVELAND 5, OHIO

"Can't think of a better argument for 'Monel' Pickling Equipment!"



Cross-sectional view of two tie-rods after one year's service on a wooden pickling tank. Note how the Monel rod is unchanged, while dealuminumification has penetrated ⅛" into the other rod.

This pickling-room foreman is talking about "safety."

"Safety" that Monel* brings to pickling equipment.

Here's what we mean: Monel does not contain alloying materials which are eaten away by pickling acids, leaving only a crumbly, low-strength mass. (Such attack is known as "dezincification" or "dealuminumification".)

This deterioration goes on . . . but you don't see it on the surface. Only when you break open a member and look at the cross-section, do you realize what is happening.

The views on the left tell this story clearly. The lower 1"-diameter tie-rod has suffered dealuminumification to a depth of ⅛". *That means that 44% of the original cross-sectional area is now useless!*

With Monel, however, this threat does not exist. In Monel you have the needed corrosion resistance as well as lasting strength and toughness.

In Monel you get *extra safety!*

*Reg. U. S. Pat. Off.

EMBLEM OF SERVICE INCO NICKEL

"Pick" Monel for all types of pickling equipment. It can be fabricated to your needs out of economical, standard mill forms. For more information on Monel and Monel fabricators, write our Ray Reddell.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York 5, N. Y.

"MONEL*" Pickling Equipment means *Extra* CAPACITY . . . *Extra* LIFE . . . *Extra* SAFETY

How Bliss Met Revere's Tough Rolling Mill "Specs"

Smooth-surfaced non-ferrous strip to exceptionally accurate, uniform gage...quick, precise adjustment during rundowns...variable, fast rolling speed ...extreme versatility throughout...those were requirements for three new rolling mills that Revere Copper and Brass put up to Bliss.

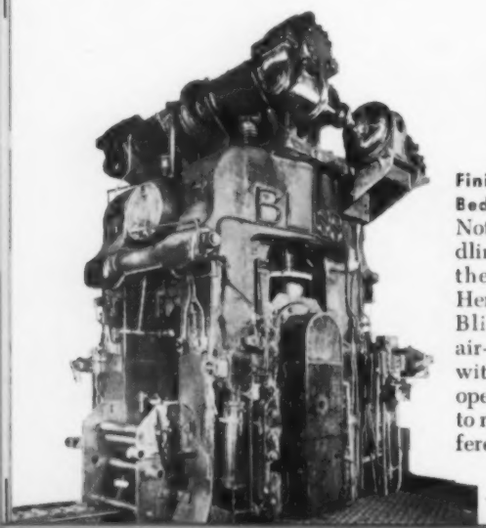
"We knew what we wanted," says H. A. Ray, Assistant Plant Engineer at Revere's New Bedford Works, "and Bliss was able to deliver. On our new intermediate rundown mill there's a collapsible block with vertical-type wrapper with an Up Coiler for heavier gage. We use the Up Coiler for strip from about .125" down to .060"—then we use the block for metal down to .016". This arrangement is compact, and I can tell you it's efficient.

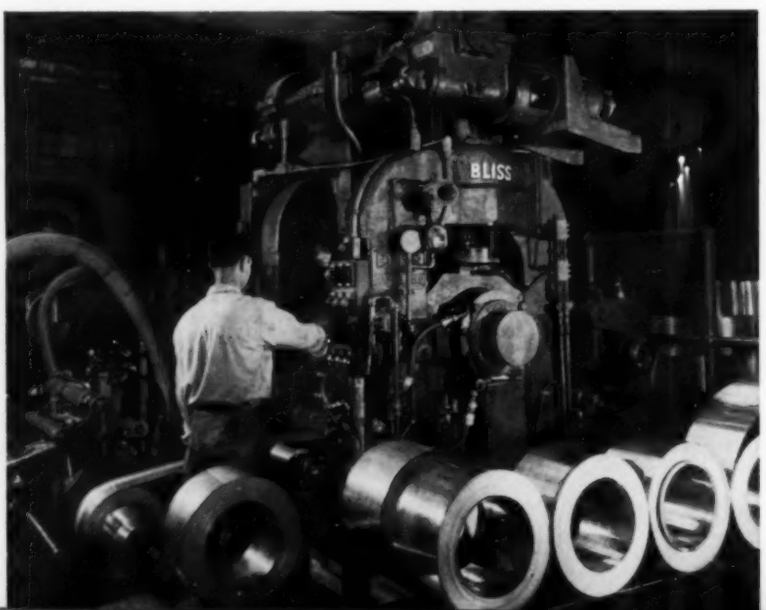
"Another thing we like is the air-operated sticker guide that Bliss developed to meet our various width requirements. On our new finishing mill, they gave us air-operated side guides immediately adjustable to handle any width we're running. On that mill, we can roll copper strip down to .005"—true to gage, 24 hours a day."

Precision Rolling to "Tenths"

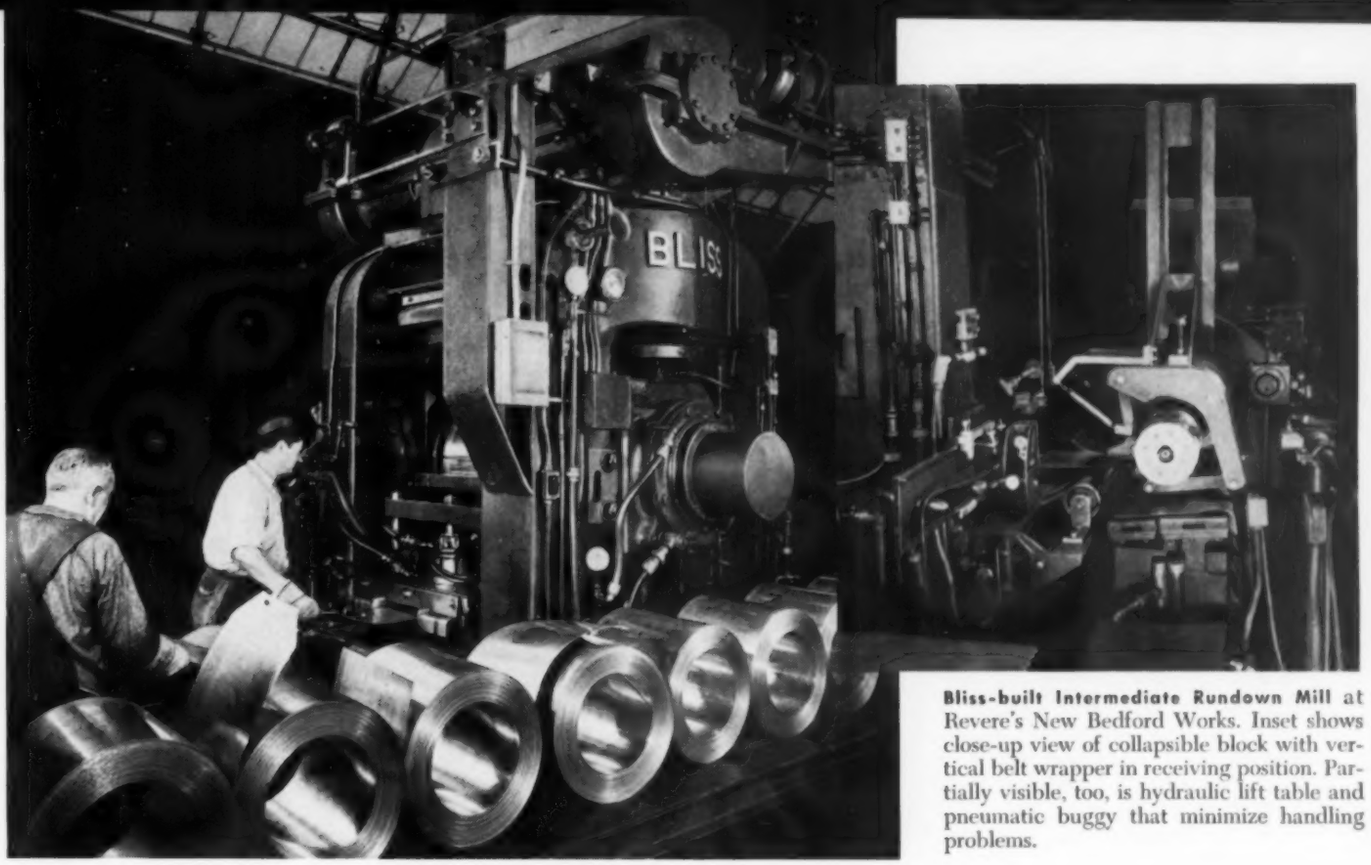
Down in Baltimore, at Revere's Canton Works,

"Old Faithful"—This 14" and 29" x 30" 4-high mill for 1st rundown of copper and copper alloy strip has seen continuous service in Revere's New Bedford plant for over 17 years.





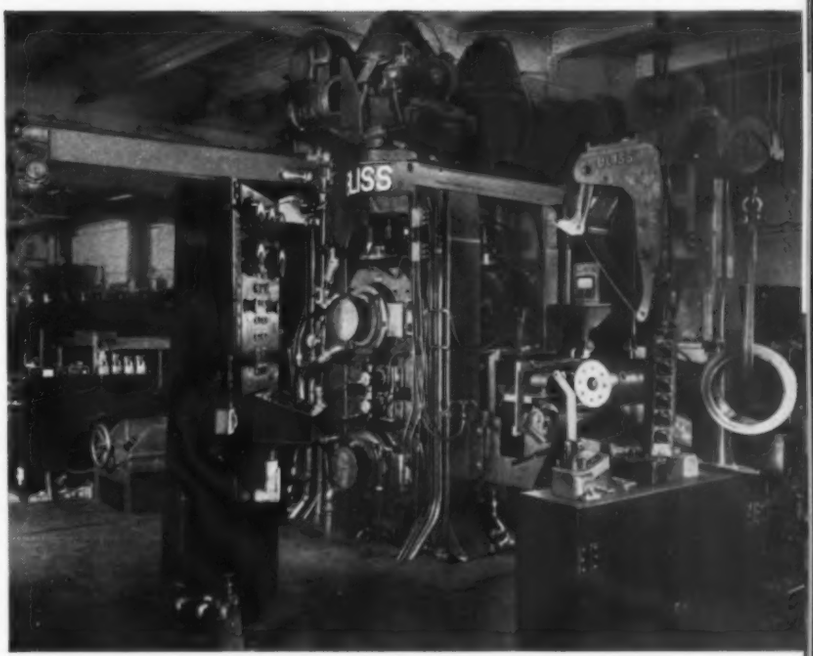
Finishing Mill at New Bedford Threads Up. Note the sleeve handling mechanism at the receiving end. Here, too, is another Bliss original—the air-operated sticker with adjustable air-operated side guides to rapidly handle different coil widths.



Bliss-built Intermediate Rundown Mill at Revere's New Bedford Works. Inset shows close-up view of collapsible block with vertical belt wrapper in receiving position. Partially visible, too, is hydraulic lift table and pneumatic buggy that minimize handling problems.

there's an even more spectacular story. Here Revere precision-rolls copper strip to .012" *within .0002"*—using a Bliss-built mill specially engineered for the job. There's variable, synchronous tension on pay-off and wind-up reel to assist in run-down, and instantaneous control of tension, winding speed and screw-downs from roller's centralized control panel. It's smooth-surfaced strip—double-checked with X-ray Thickness Tester and air micrometers.

Yes, for the engineered refinements that make for maximum production—for the rolling mill performance you want, put your problem up to Bliss. You'll get the same keen counsel that's made Bliss the first name in presses for more than 90 years.



"Tape Mill" at Canton Works in Baltimore—designed for precision-rolling of copper tape for coaxial cable to gage .012" within .0002". X-Ray Thickness Tester mounted on exit side gives constant gage indication and roller's control panel permits immediate correction of adjustment during rolling to hold tolerance.

E. W. Bliss Company

DETROIT 2, MICHIGAN

Manufacturers of two-, three-, and four-high mills for hot or cold rolling; single stand reversing, or tandem mills for ferrous or non-ferrous metals; cluster mills. Accessory mill equipment furnished complete.

HYDRAULIC PLATE STRETCHER-LEVELLER OF 1000 TON CAPACITY

A SELF-CONTAINED OIL-HYDRAULIC MACHINE FOR HANDLING PLATES OF FERROUS, NON-FERROUS AND CLAD METALS UP TO 132" WIDTH AND 31 FT. LENGTH

SUPPLIED TO
LUKENS STEEL COMPANY
THE WORLD'S LARGEST PLATE MILL
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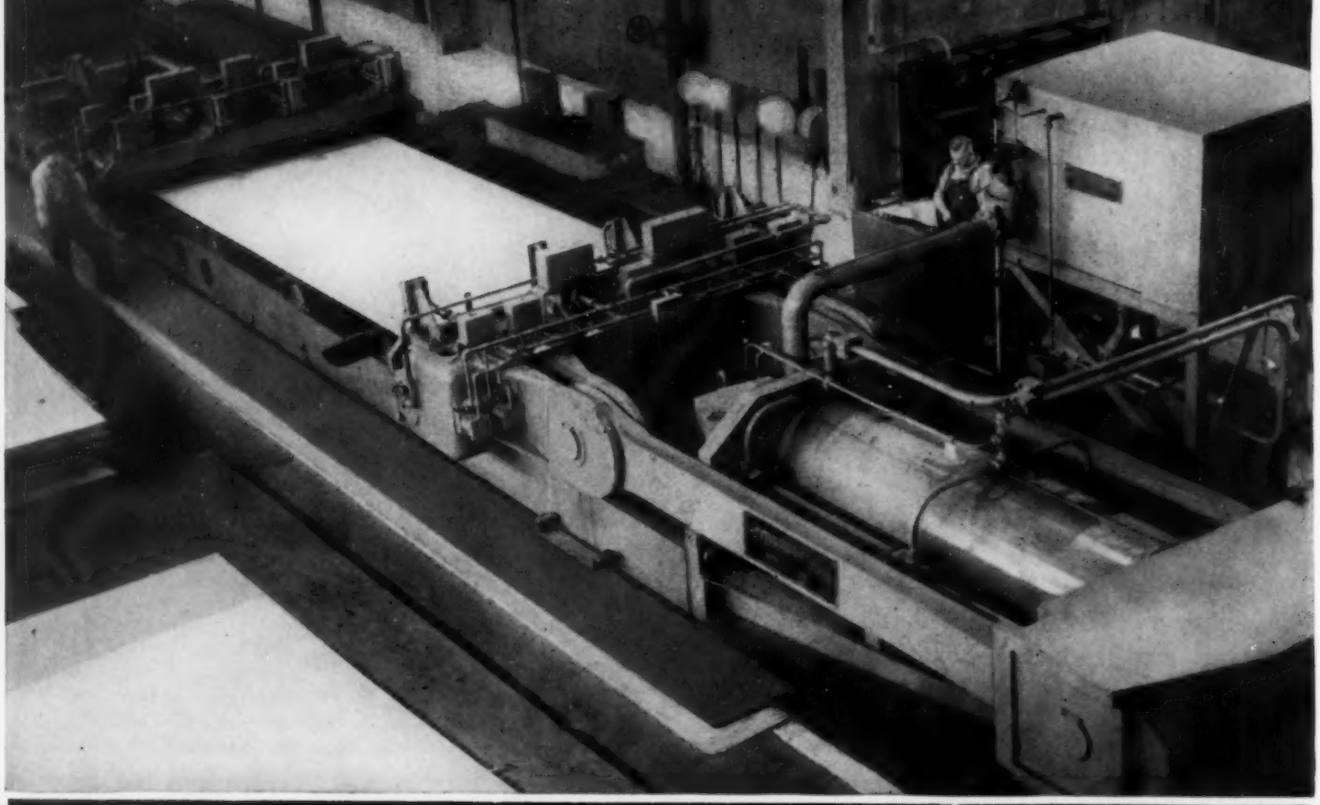

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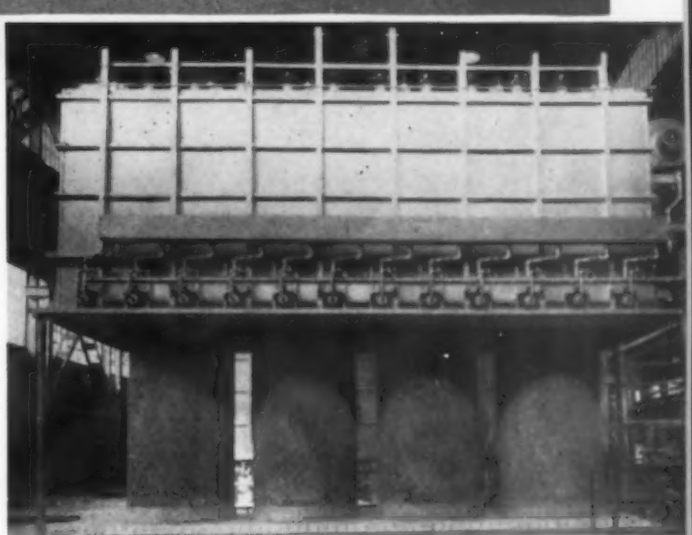
WILSON CONVECTION ANNEALING

at GRANITE CITY STEEL COMPANY

A 4-STACK CHARGE OF SHEET COILS
60" DIA. - 135" HIGH

This 4-stack Wilson Radiant Convector Furnace is one of two such units at the Granite City Steel Company. Three 2-stack furnaces of this same design are also installed at this plant.



THE CHARGE FINISHED AND THE FURNACE
IS MOVED TO THE NEXT BASE

Lee Wilson

ENGINEERING CO., Inc.

20005 West Lake Road CLEVELAND, OHIO

Telephone ACademy 4670

INDUSTRIAL FURNACES • RADIANT TUBE HEATING • HEAT TREATING PROCESSES

SPLICE WITH TIME-TESTED OKONITE AND MANSON TAPES...

FOR MOISTURE-TIGHT, ELECTRICALLY-SOUND JOINTS

6 KEY QUESTIONS ABOUT RUBBER TAPES

1. Is it made with new Up-River Fine Para — the rubber selected for the finest cable insulations?
2. Is the rubber washed thoroughly to free it of impurities?
3. Is it expertly compounded with the finest ingredients under carefully controlled conditions?
4. Does it fuse readily into one solid mass?
5. Is it high in dielectric strength?
6. Is it high in insulation resistance?

Say "YES" 6 times if it's OKONITE Rubber Tape!

6 KEY QUESTIONS ABOUT FRICTION TAPES

1. Is it made with fresh, new rubber?
2. Is it truly adhesive and not merely sticky?
3. Is it mechanically strong and does it remain strong throughout a long period of service?
4. Is the standard ¾" width able to withstand a 45-pound pull?
5. Is it closely-woven to prevent "pin-holes"?
6. Has it good aging qualities?

Say "YES" 6 times if it's MANSON Friction Tape!

THE longest-lived splices they ever made — that's what more and more electrical men are getting from Okonite Rubber and Manson Friction Tapes!

Here's why. The combination of Okonite Rubber and Manson Friction Tapes provides every characteristic essential to making a permanent joint. For example, the Okonite Rubber Tape, when applied to the insulation, self-vulcanizes into one solid wall of fused material. This wall makes the joint impervious to moisture and equal both mechanically and electrically to the original insulation. There are *no separate layers* that can open up or permit moisture to enter.

The Manson Friction Tape keeps it that way. It adds the firmly-adhering, weather-resisting mechanical protection that a well-made joint must have. By providing consistently long-lived splices, Okonite Rubber and Manson Friction Tapes make possible the economy demanded by the high installation costs of today. Using the best tapes is the best policy when you consider the seriousness of an electrical failure and the doubling of installation expense whenever a joint has to be rebuilt.

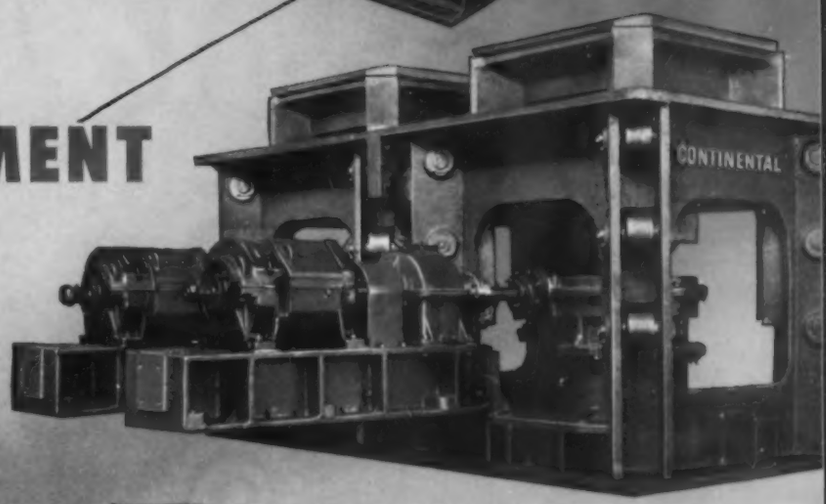
To see for yourself what kind of splices you get with these time-tested tapes, simply use your business letterhead to request a sample of each — enough to make more than a dozen splices on #6 wire. Address The Okonite Company, Passaic, New Jersey.

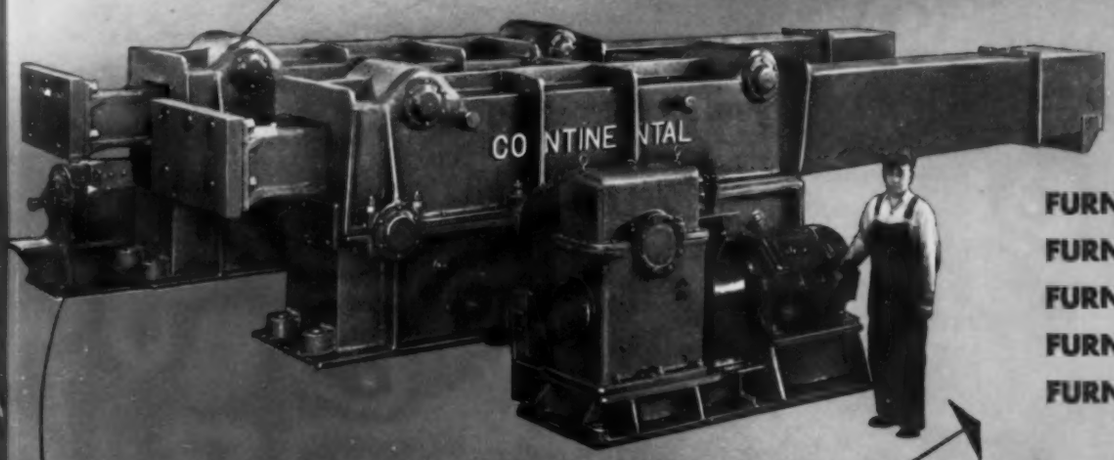
7109

OKONITE and MANSON TAPES

for AHEAD-OF-THE-FIELD engineering

REHEATING
FURNACE EQUIPMENT
by Continental





FURNACE RUN-IN TABLES
FURNACE RUN-OUT TABLES
FURNACE PUSHERS
FURNACE BUMPERS
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Industry's Headquarters for
Rolling Mills and Equipment
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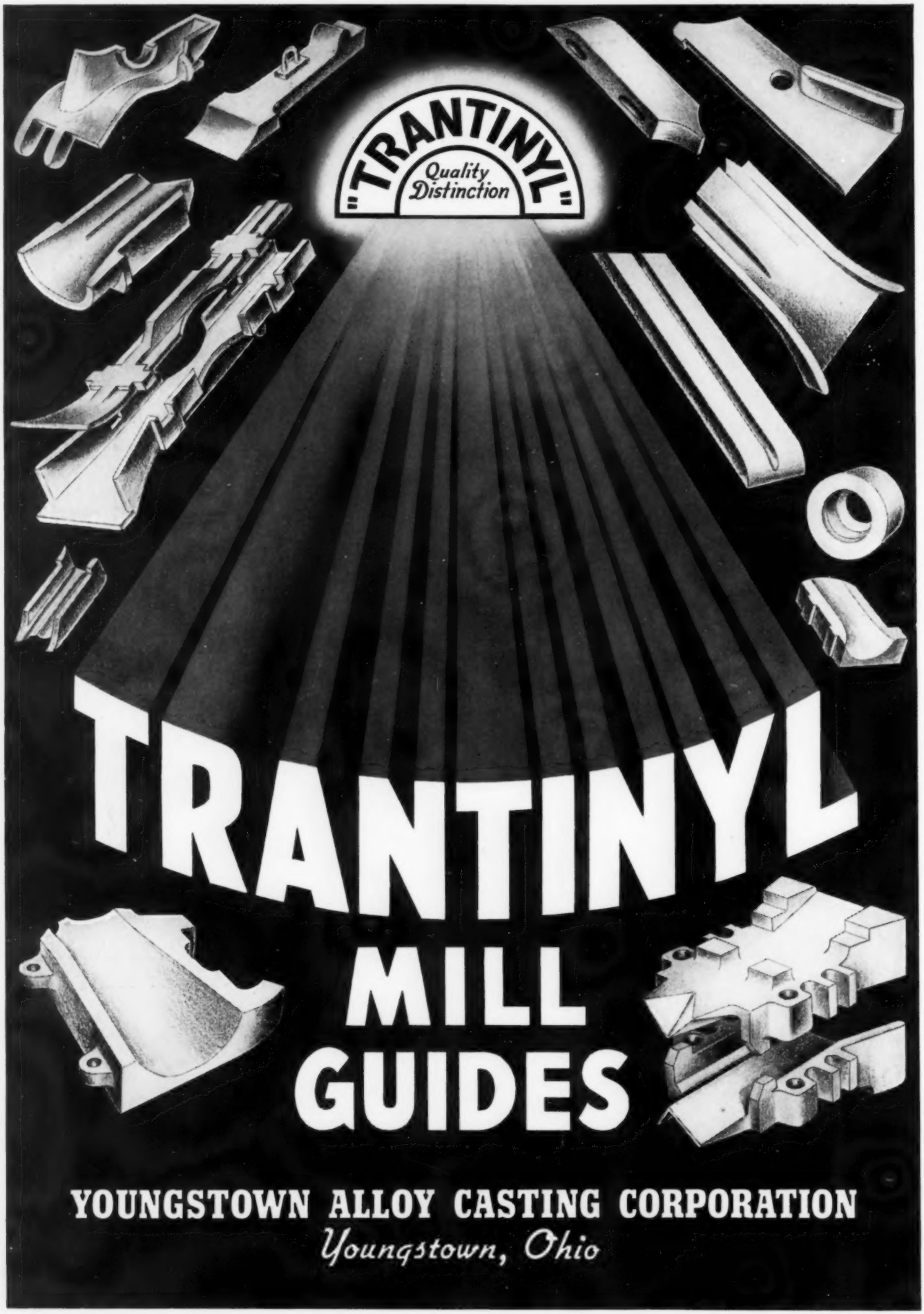
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YOUNGSTOWN ALLOY CASTING CORPORATION
Youngstown, Ohio

CLARK SLASHES DELIVERY TIME

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4 to 6 WEEKS!

Greatly increased plant production capacity now makes possible the prompt fabrication of CLARK Standard Magnetic Crane and Mill Auxiliary Controllers . . . NEMA STANDARD Section IC-14 and Section IC-13 respectively.

These are standard Open Type CLARK Crane and Mill Auxiliary Controllers—*no cabinets,* including necessary accessories such as Master Switches, Resistors, etc.

Contact our Nearest District Office for details.

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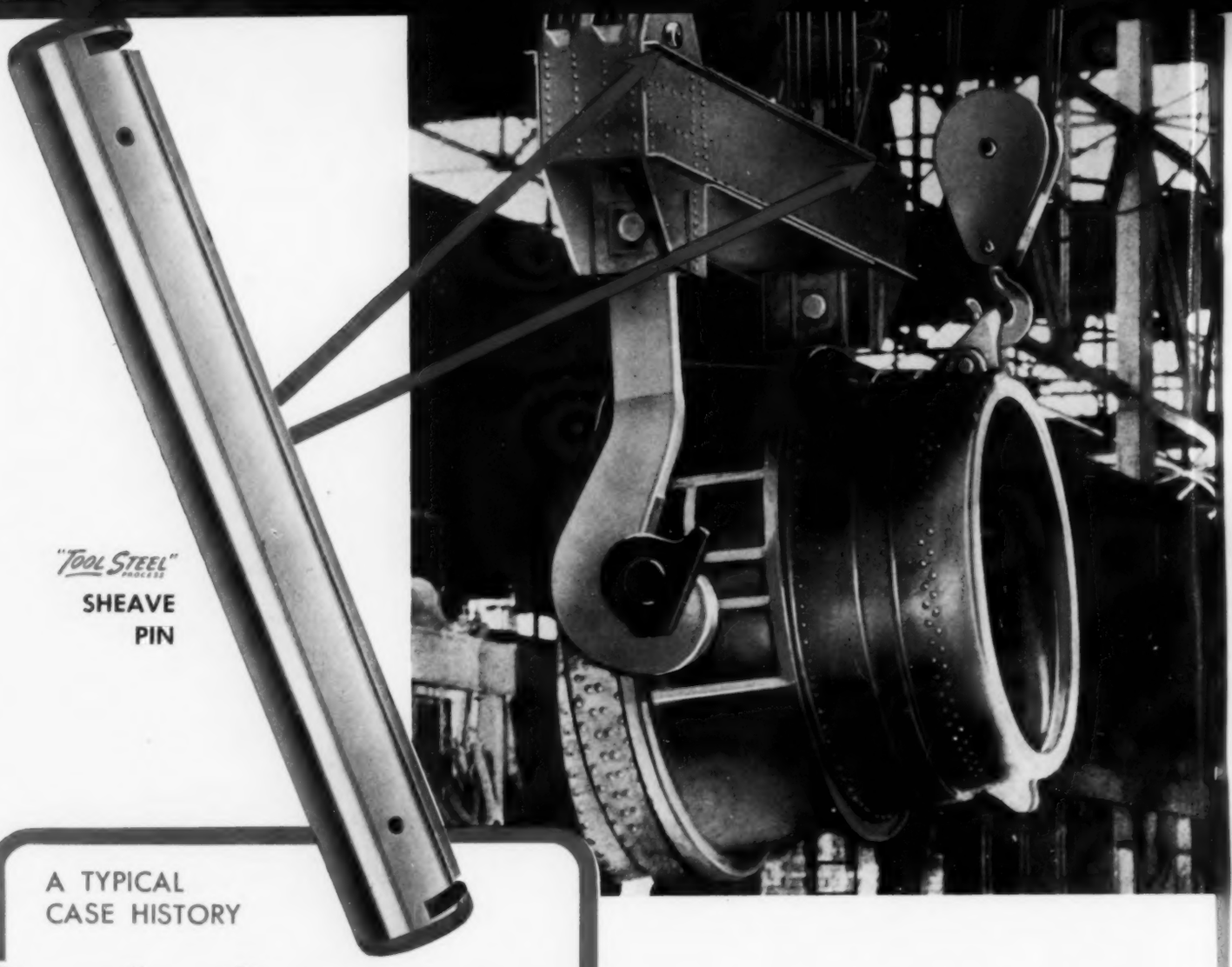
THE CLARK CONTROLLER CO.

EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO



"TOOL STEEL" PROCESS
SHEAVE
PIN

A TYPICAL
CASE HISTORY

"Bushed" BUSHINGS are few and far between with "TOOL STEEL" PROCESS sheave pins

Product . . . . "Tool Steel" process sheave pins in service on hot metal mixer crane as shown above.

Plant . . . . . In use by one of the world's largest steel companies. Name on request.

Service Record Installed June 27, 1941 and replaced October 14, 1946, after handling 3,535,193 tons. During this period sheave wheels and bushings were changed only twice!

Comments . . . "Tool Steel" pins showed a tonnage superiority of 13 to 1 over ordinary heat-treated pins which were used previously. Competitive pins lasted five months, completely wore out their bushings, and handled only 272,614 tons! This is another example of "Tool Steel's" superiority!

Changing bushings is an expensive, time-consuming operation, but there is something you can do about it!

Specify "Tool Steel" sheave pins and your maintenance is materially and immediately reduced.

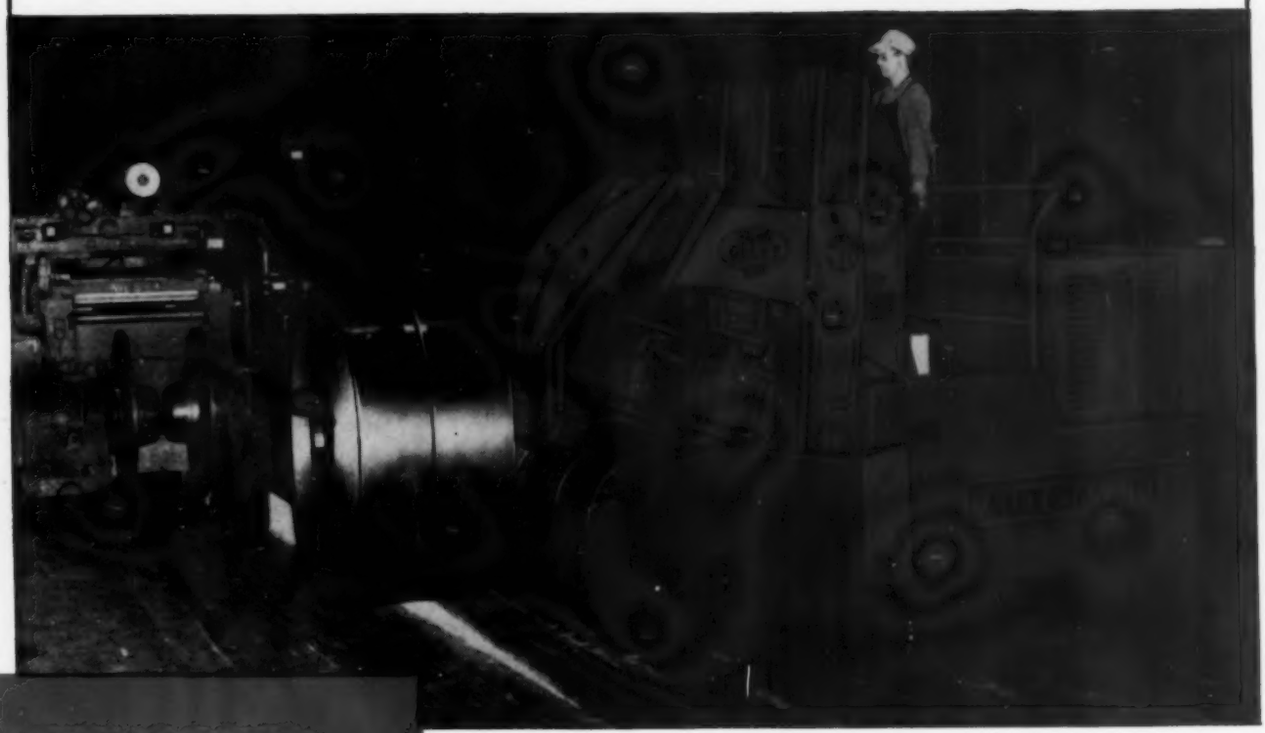
Here's why! The surface of "Tool Steel" pins tests from 85 to 90 scleroscope (635-700 Brinell), deep enough for the life of the pins. This guarantees a true surface even under the most severe operating conditions and prevents unnecessary wear on bushings.

The costs are comparable to ordinary pins, but your savings with "Tool Steel" are substantial. Write today for complete information.

THE TOOL STEEL GEAR & PINION CO.

CINCINNATI 16, OHIO

How Skylift GIANTS help produce more steel, faster!



ABILITY TO HANDLE 25,000 POUND STEEL COILS GIVES PRODUCTION TERRIFIC BOOST AT GRANITE CITY STEEL CO. NEW COLD STRIP MILL

In the effort to boost steel output, part of the solution has been found in the design of faster strip mills, capable of processing larger quantities of metal in a single operation and at increased speed. But, the new mills themselves added to the problem. How were they to be fed with the huge coils of steel they were capable of handling?

Granite City Steel Company, Granite City, Illinois, found the answer in the Skylift GIANT!

Operating at full speed, its new cold strip mill will produce enough steel in a 24-hour period to stretch from New York to St. Louis. Literally making this possible, are the Skylift GIANTS.

Huge coils weighing from 15 to 25,000 pounds are moved by Skylift GIANTS to the tandem cold strip mill where the hot rolled coil is reduced to cold strip. Again Skylift GIANTS move the coils to the electrolytic cleaner for removal of rolling oils.

And through every process until the tinplate is ready for shipment, Automatic's mighty giants of electric power handle coils large enough to meet every requirement of speed in delivering to and discharging coils from the mill. Result is 25% more coils processed at capacity operation.

Skylift GIANTS are specially engineered to handle all sizes, all weights of coils.

Four front drive wheels provide as much as 80 inches of rubber. Pivoted drive axles give constant 4-wheel traction regardless of floor conditions—controlled caster type trail axle, center-pivoted, compensate for uneven floor surfaces. Nearly 20% lighter in proportion to load capacity than other heavy-duty fork and ram tractors —Skylift GIANTS are the only heavy-duty trucks with HIGH PRESSURE HYDRAULIC LIFT that eliminate chains and sprockets.

MAIL COUPON TODAY

Mail coupon for facts about how Skylift GIANTS offer *your business* amazing production and handling savings.

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A PRODUCT OF AUTOMATIC

Lightens Labor's Load

AUTOMATIC TRANSPORTATION COMPANY

DIV. OF THE YALE & TOWNE MFG. CO.

47 W. 87th St., Dept. B-9, Chicago 20, Ill.

☐ Send details on Automatic's Skylift GIANTS Fork and Ram Trucks.

Company Name.....

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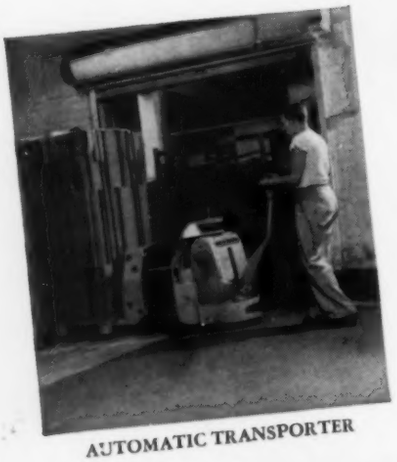
Street Address.....

City.....

Zone.....*State*.....

Manufacturers of the Famous Transporters, Transtackers and Skylift Electric Trucks



AUTOMATIC TRANSPORTER

AUTOMATIC FORK LIFT TRUCK

Time Savers, Cost Cutters

Battery Electric Trucks and EXIDE-IRONCLAD BATTERIES

Handle materials the modern way . . . the fast, safe, economical way. Use versatile battery electric trucks for loading, unloading, hauling, high tiering. They'll help you speed production, open up bottlenecks, save and earn for you all along the line. When powered by dependable Exide-Ironclad Batteries, you can count on full shift availability day after day, year after year.

Different from all other batteries in construction as well as in performance, the Exide-Ironclad possesses ALL FOUR of the essential characteristics demanded of a battery for electric industrial truck service—(1) high power ability, (2) high efficiency, (3) great ruggedness, and (4) long life. These characteristics are due to the special construction of the Exide-Ironclad Battery, especially its rugged, tubular positive plate.

Write for further particulars and FREE copy of Exide-Ironclad Topics, which covers latest developments in materials handling and shows actual case histories.

1888...DEPENDABLE BATTERIES FOR 61 YEARS...1949

"Exide-Ironclad" *Reg. Trade-Mark U. S. Pat. Off.*

DEPENDABLE POWER

THE ELECTRIC STORAGE BATTERY COMPANY
Philadelphia 32
Exide Batteries of Canada, Limited, Toronto

TAKE *QUALITY* FOR GRANTED

SPECIFY *LINK-BELT* BALL AND ROLLER BEARINGS

You can **Depend** upon LINK-BELT for:

1 QUALITY
2 PERFORMANCE
3 ECONOMY
4 ACCEPTANCE
5 COMPLETENESS
6 SERVICE

There's no question about the high quality of Link-Belt Ball and Roller Bearings.

Considering the precision manufacturing processes, the skilled use of the most modern equipment under closest control, and the years of scientific research to furnish industry with longer-lasting, more efficient bearings, it is little wonder that "Link-Belt" quality is unquestioned.

Eliminate all guesswork — specify "Link-Belt" on your next bearing order. Choose with the utmost confidence from the COMPLETE Link-Belt line . . . various mountings and sizes for practically all types of industrial applications.

Good supplies of these popular bearings await your commands at distributor's and Link-Belt stockrooms throughout the nation.

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Free Catalogs On Request!

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Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.

LINK-BELT
BALL AND ROLLER BEARINGS

EVERYONE SAVES WITH *Pennsylvania*

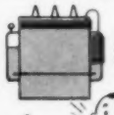
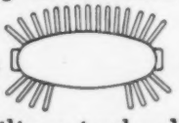
STANDARD PARTS POWER TRANSFORMERS

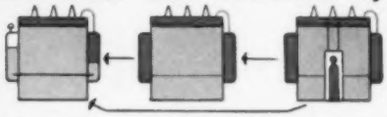
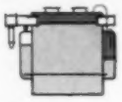
Lower Prices and Faster Deliveries For You

Economy in Manufacturing For Us

Pennsylvania Transformer Company introduces a line of Power Transformers that was carefully designed to include the desirable features of custom-built transformers, at quantity production prices. Streamlined and standardized methods of manufacture, coupled with the use of standard designs and standard parts, shorten engineering and production time. This reduces the price of the transformer and shortens the delivery time. Of special interest is the fact that these Standard Parts Transformers can be supplied with any of the popular methods of oil preservation.

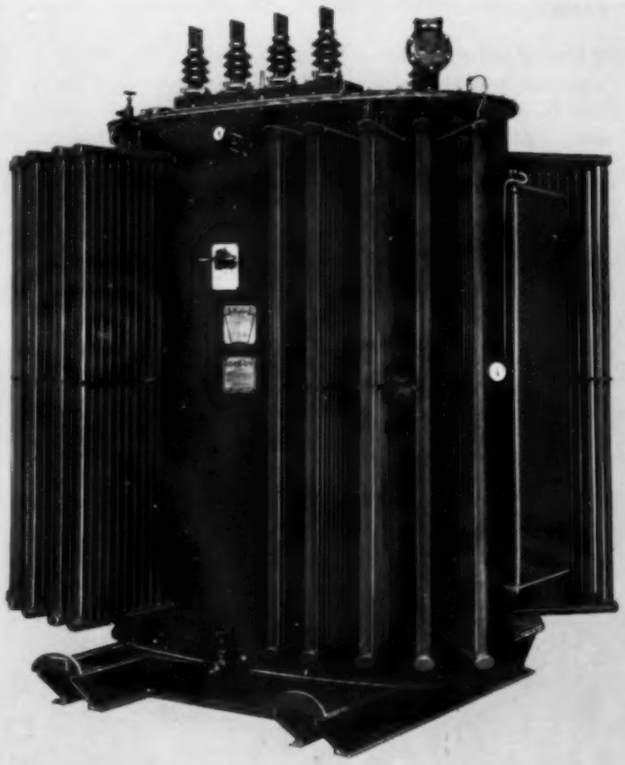
HERE IS HOW IT'S DONE:

We begin with a transformer that falls within the standard design ratings and add two auxiliary tanks. An auxiliary tank is welded to each end of the transformer tank. These auxiliary tanks are connected to each other and to the main tank by tubing, to form the following Oil Preservation Systems: Inert Gas-Oil Seal  Sealed Tank and Inert Gas Pressure System. "Ingenious," you say! Well, we call it good engineering and functional design. For example, when the radiators are applied to the transformers,  in most cases they extend beyond the auxiliary tanks, so the addition of these auxiliary tanks does not increase the projected floor area. Because these auxiliary tanks are permanently welded to the transformer tank, they offer no problems of installation and extra maintenance. But that's not all! All Standard Parts Power Transformer tanks, regardless of the type of oil preservation, are filled with the same quantity

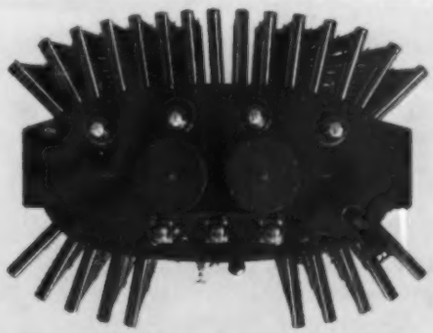
of oil, with the extra gas and oil spaces provided in the auxiliary tanks. Thus, bushings with standard (normal) length shanks are used on all Standard Parts Power Transformers, and no special-size bushings need be stocked. What is more, the unique construction permits the user to change the method of oil preservation without difficulty and without adding any parts. Sealed Tank can be changed to Inert Gas-Oil Seal; and Inert Gas Pressure System can be changed to Inert Gas-Oil Seal or Sealed Tank.  Pennsylvania Standard Parts Transformers can be provided with conventional Oil Expansion Tanks in which case the auxiliary tanks are left off. However, all the other advantages of the Standard Parts design are maintained. When called for, throats with horizontal side-wall bushings can be located on the ends of the transformer. In addition, extra compartments for potheads, disconnect switches, etc.,  can also be added to the Standard Parts Transformer.

These are just a few of the outstanding design features of Pennsylvania's entirely new Standard Parts Power Transformer. For more information write for Booklet No. 1492.

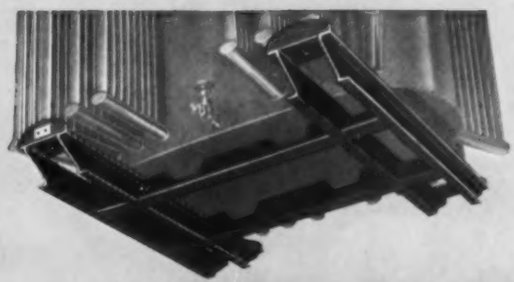
Now available in the following sizes:
Three Phase: Up to 10,000 Kva, 34 Kv.
Single Phase: Up to 5,000 Kva, 34 Kv.



Standard Parts Power Transformer. 3750 Kva, 3 Phase, 60 Cycles, OA, 55°C. Voltage: 12,000 Delta-4,160 Y.



Top of 4000 Kva Standard Parts Transformer. Note how auxiliary tanks fit into ends of the transformer and do not add to the length of the transformer.



Base for Standard Parts Transformer. Base is designed to simplify jacking, pulling, rolling, and painting.

Pennsylvania TRANSFORMERS

Pennsylvania
TRANSFORMER COMPANY
PITTSBURGH 12, PENNSYLVANIA

A-B-K Laminated Plastic Bearings

Cut Costs 4 Ways

A-B-K roller neck bearing with separate collar.
A-B-K patented reinforced edge slipper bearing, made to specified blueprint sizes.
Phantom view of A-B-K reinforced edge slipper bearing.
1. Outwear Metallic Bearings
2. Reduce Power Consumption
3. Eliminate Lubricating Oil
4. Require Fewer Adjustments

Steel mill records clearly prove that when metallic bearings are replaced with A-B-K Laminated Plastic Bearings, production goes *up* and costs come *down*. Specifically, A-B-K bearings cut costs four ways:

Outwear metallic bearings—A-B-K laminated bearing material is extremely tough and slow-wearing. It is impervious to mild acids and alkalies, will not distort under shock and withstands temperatures up to 200° F. without failure. In actual service, A-B-K bearings customarily outwear metal several times.

Reduce power consumption—A-B-K Laminated Plastic Bearings have an exceptionally low coefficient of friction which produces remarkable savings in power. The A-B-K surface is self-renewing—actually polishes, but never scores, the shaft.

It will pay you to investigate fully the cost-cutting advantages of A-B-K Laminated Plastic Bearings for your mill. The complete engineering and research facilities of American Brakeblok are at your disposal... Write to arrange a consultation.

Eliminate lubricating oil—A-B-K bearings are successfully lubricated with *water*. Cost of oil or grease is eliminated entirely.

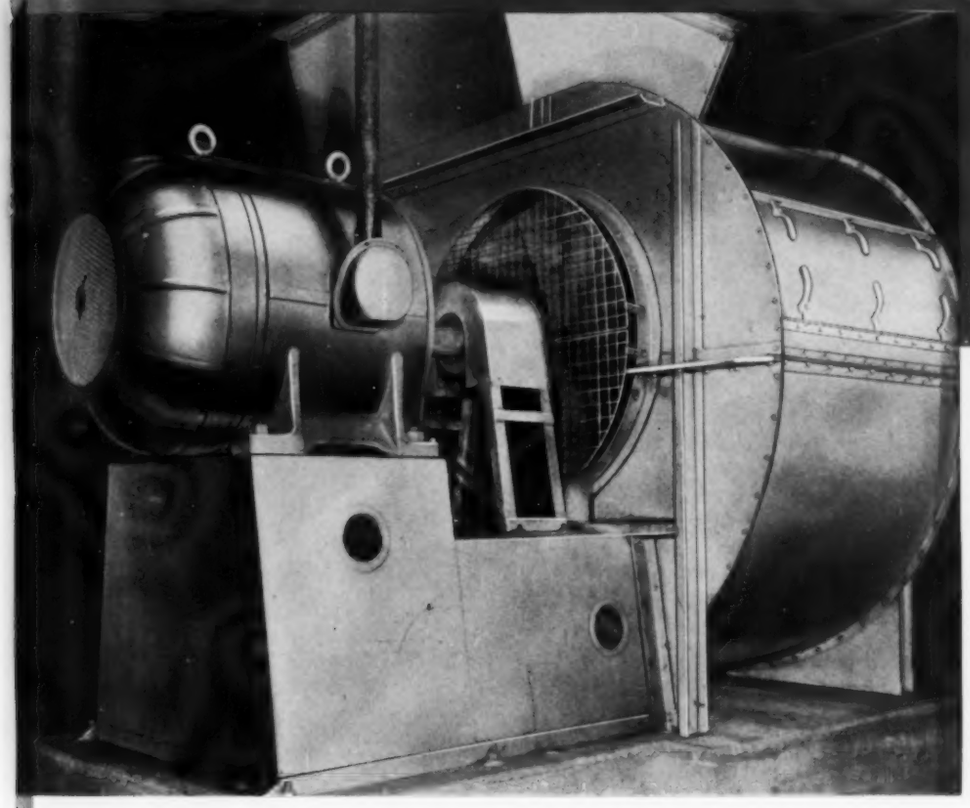
Require fewer adjustments—Because A-B-K bearings hold gauge longer, oversize requirements and need for roll adjustments are sharply reduced. This means fewer shutdowns—a higher percentage of productive time from each A-B-K equipped unit.

A-B-K
Laminated Plastic Bearings

AMERICAN Brake Shoe COMPANY

AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

Fighting Mill Motor HEAT -TO KEEP 'EM HUMMING!



"Buffalo" Fan giving 24-hour motor cooling service in a prominent mill.

"Buffalo"

MILL MOTOR FANS

FACTS TELL THE STORY

Write for complete performance data on these rugged fans, or call in your "Buffalo" representative. There's one in every principal city.

KEEPING mill motors cool takes a lot of air! As mill men know, this calls for fans that can work "around the clock" against pressure and heat with little maintenance attention.

The "Buffalo" Fans in such installations are taking this tough service and coming right back for more. That's because they're "built up" to the job.

Heavy plate housings like those in stoker fans — oversize shafts and bearings — rigid, heavy rotors are all part of this overall rugged "Buffalo" construction. This durability is matched by the inherent "Buffalo" efficiency that means more air delivered for less power consumption!

"Buffalo" "First For Fans"

PERMANENT SATISFACTION IN AIR HANDLING

BUFFALO FORGE COMPANY

VENTILATING — AIR TEMPERING
FORCED DRAFT — HEATING
AIR WASHING — INDUCED DRAFT
COOLING — EXHAUSTING
PRESSURE BLOWING

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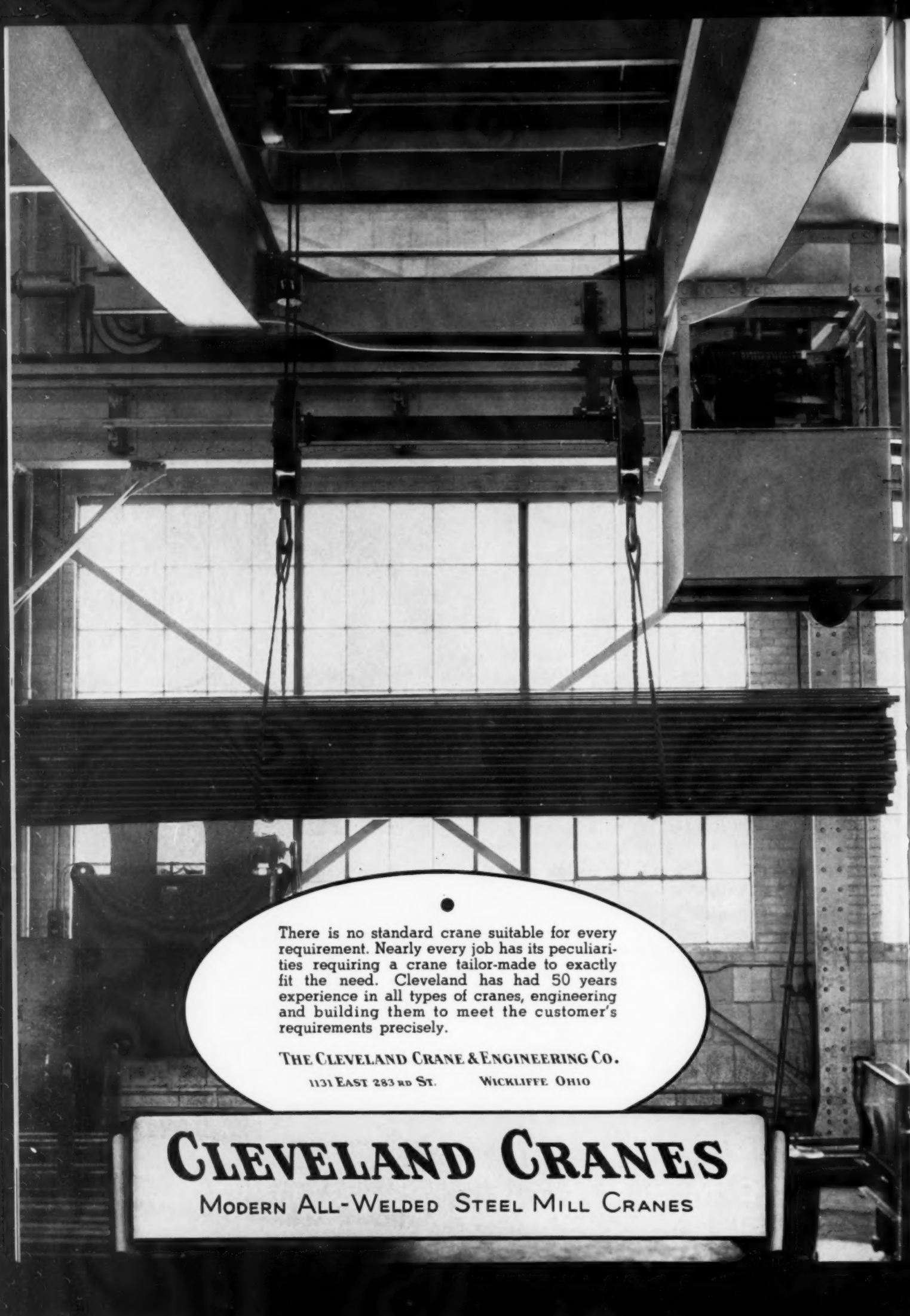

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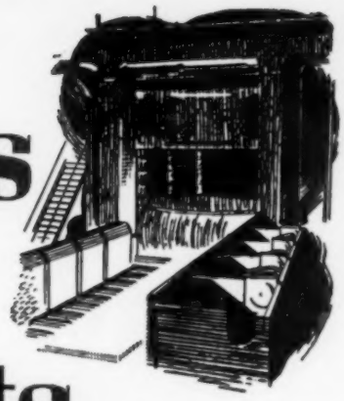


PRESIDENT TRUMAN nonchalantly remarked to a recent news conference that he has always contended steel prices were too high and he still thinks so. Thus, steel is again singled out as the whipping boy — not other metals, not foodstuff, not clothing — but steel, which has had only a fraction of the increase enjoyed by almost every other commodity over prewar prices.

Admittedly, the total dollar volume of current profits are high. But why overlook the fact that one-half to three-quarters of those profits must go back into the plants to help inadequate depreciation reserves pay for necessary rehabilitation? Why overlook the fact that only a portion of the so-called profits go into dividends to the investor, who has risked his capital to set up the plant and make jobs for thousands of people?

The prewar history of United States Steel Corp. shows incomes before taxes, in per cent of sales, varying with operating rates according to the following averages:

Per cent operation	Per cent income on sales
47	0
60	5
80	12
100	19

Against these figures, 1947 showed an income of 6 per cent of sales volume at an operating rate of 96.7 per cent, while 1948 will show about 5.2 per cent income with 93.8 per cent operation — both considerably below the averages of prewar history, and both below the level of exorbitant returns as measured by industry in general.

No doubt the statement was prompted by the seemingly large profits reported by steel companies, without regard for all factors entering into the overall picture. No doubt it was seasoned by an inherent distaste for the industry that has disputed criticism of its ability to meet the demands upon it. But this does not make the statement less unwise, or less inflammatory to unthinking people.

▲

A suggestion for overcoming some of the burden of plant modernization at present prices was advanced by Admiral Ben Moreell, president of Jones & Laughlin Steel Corp. He suggests a change in the federal tax law to allow more rapid amortization of the cost of new equipment. He proposes that companies be allowed to write-off up to one-half of equipment costs within one to five years, as they choose, and that they be allowed to deduct this amortization from taxable income. He also proposes that a limit be set on the amortization deducted in any one year at one-half of the taxable income for that year before amortization is deducted.

Industry is allowed to make deductions for the higher costs of operating materials and labor, but there is no relief for costs of plant and equipment, which have more than doubled. If this change were made, it would be essentially only a deferment of payment, since companies that used up its tax deduction for write-off now could deduct less in future years. Admiral Moreell's plan would give industry more working cash, now when it is needed, and would help the steel industry to modernize faster.

▲

AND speaking of high prices, a powerful group of southern Democrats plan to fight for permanent support for basic crop prices at the wartime 90 per cent of parity level. The current law keeps the 90 per cent through 1949 and then drops to 60-90 per cent, depending on production. Whether prices seem high or low merely depends on where you're standing.

▲

WE wonder just how many animals would be wearing their own furs this winter if it were not for installment plans.

▲

WE see that the power transformers built with silver windings during the wartime scarcity of copper are being torn down and rebuilt with copper windings. The silver will no doubt be put back in the ground at the government silver board at West Point, N. Y. It seems to us that the copper, in other applications, might still be more useful than the silver in the ground. Now if we could just find some use for the gold at Fort Knox.....

▲

THE cigarette production of the United States in 1948 was 387,000,000,000. We can't imagine why anyone would be interested but, laid end to end, they would reach the moon and back to earth 35 times, or they would circle the equator 672 times.

▲

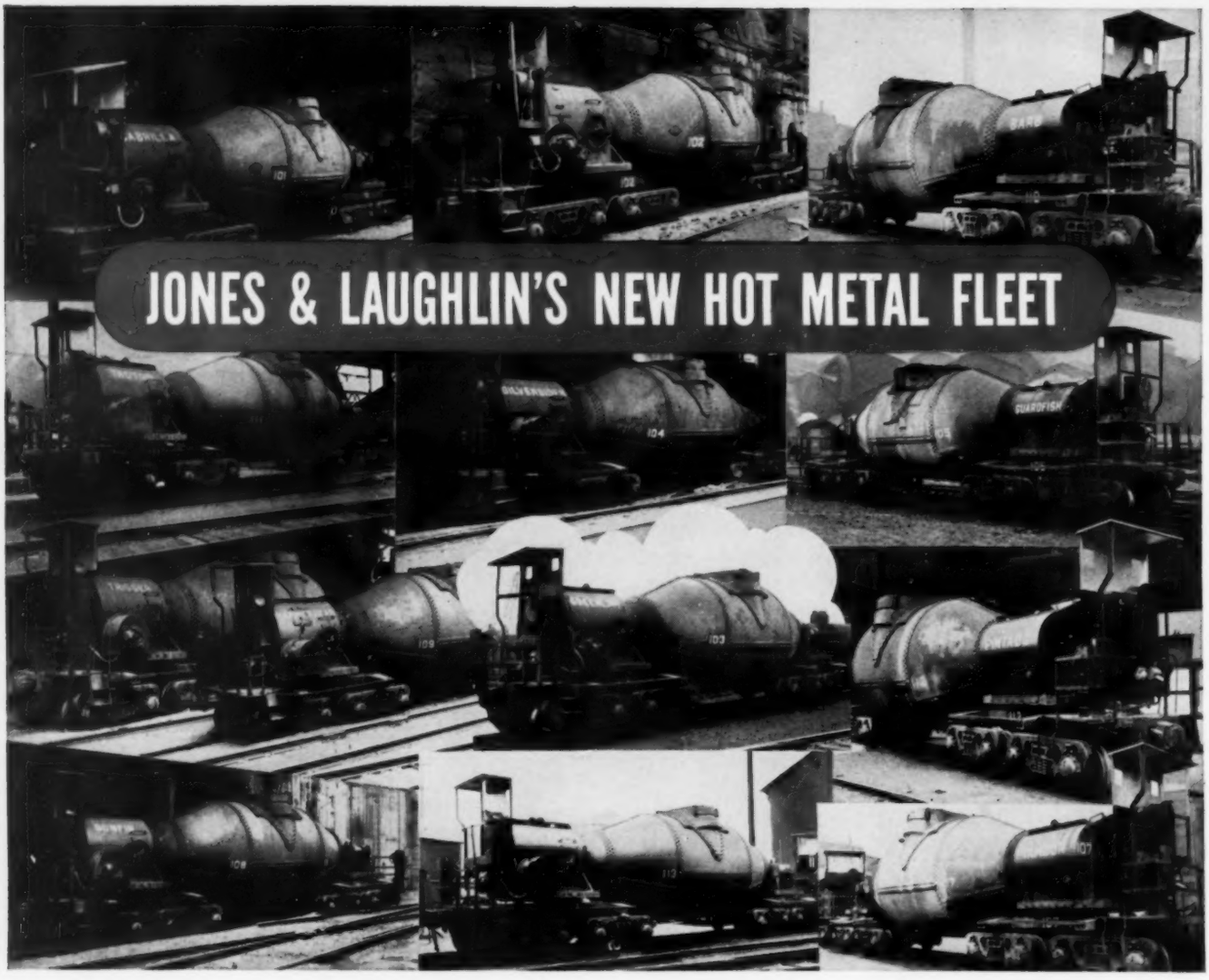
THE 1948 production of pig iron and ferro-alloys totaled 60,848,840 tons, a figure exceeded only by the wartime years of 1943 and 1944. Blast furnaces operated at 90.2 per cent of capacity.

For the same year, production of iron ore in the United States totaled 101,350,000 gross tons, of which 83,116,000 tons came from the Lake region, 8,201,000 tons from the southern district, 4,472,000 tons from northeastern states, 5,018,000 tons from the west, and 543,000 tons from miscellaneous sources as a by-product.

And while on the subject of blast furnaces, Bethlehem Steel Co. is open for congratulations for setting a new world production record of 54,336 net tons of iron during December, 1948, on "H" furnace, a 28 ft hearth stack at Sparrows Point.

▲

MODERN youth defines father as a dope who is too dense to do anything but make the money that keeps the family going.



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Photos courtesy Ford Motor Company

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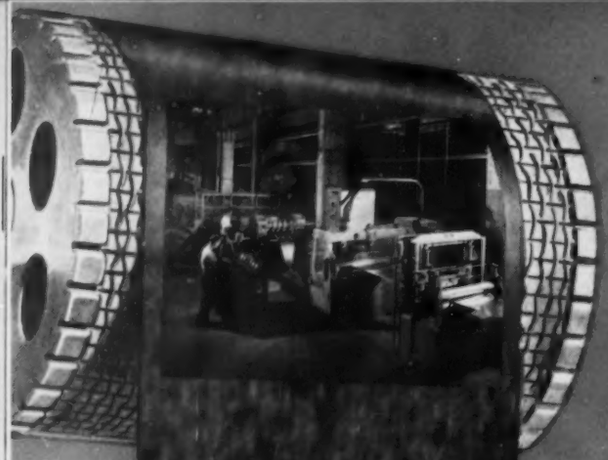

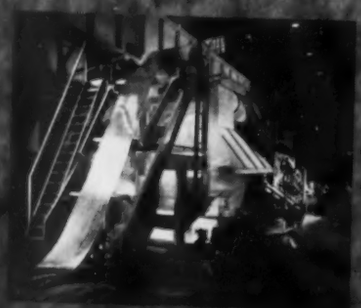

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Iron and Steel ENGINEER

FEBRUARY, 1949 VOLUME XXVI NUMBER II

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Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expression of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

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Indexed by Engineering Index and by Industrial Arts Index.

Single Copy Foreign Prepaid $2.00 Single Copy $1.50
Subscription price in U. S. and Canada (U. S. funds) ..... $ 7.50 per year
Subscription price in foreign countries ..... $10.00 per year

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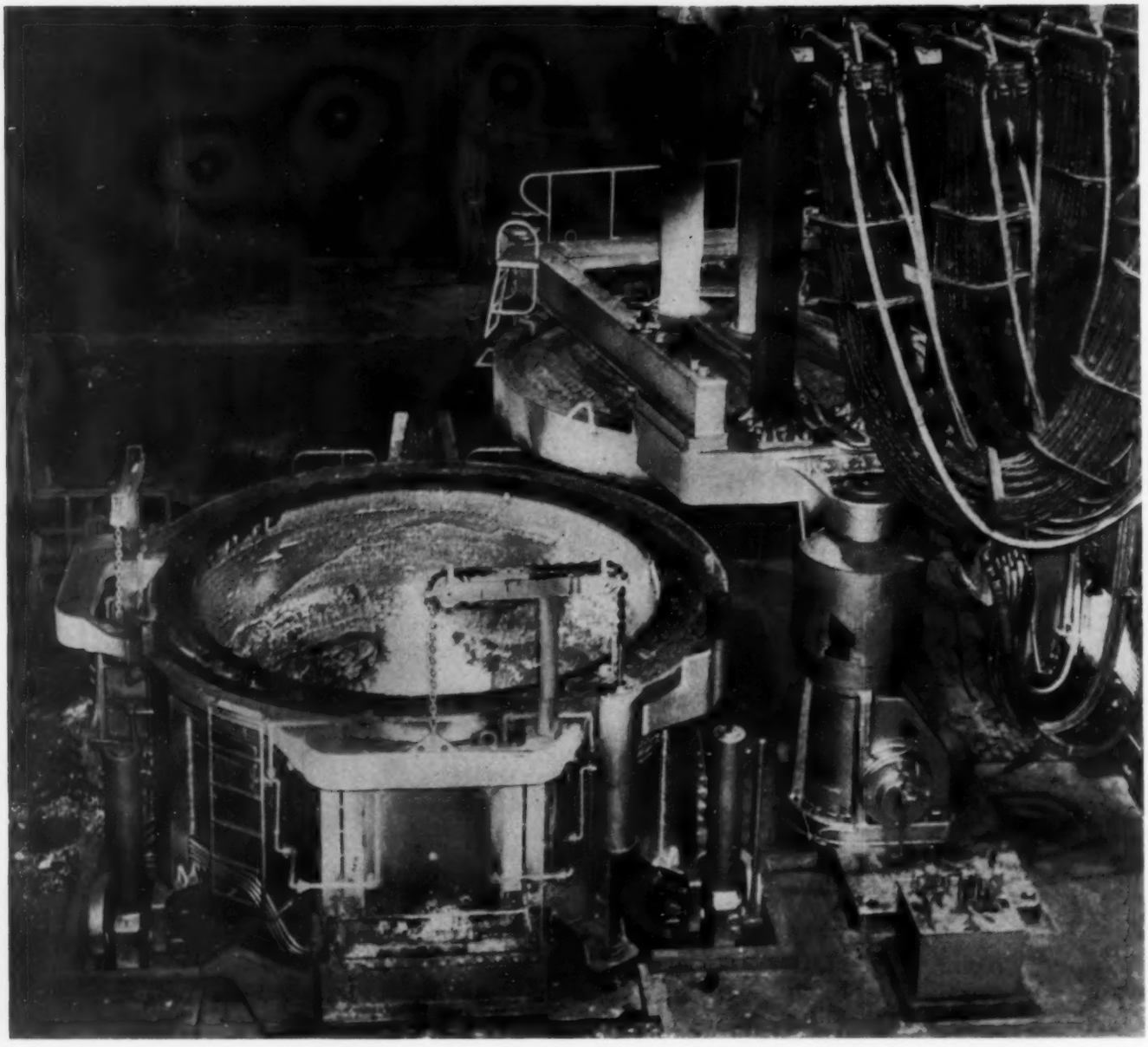

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DEFORMATION IN ROLLING

By GEORGE S. MICAN
Division Superintendent, Rolling
Carnegie-Illinois Steel Corp.
South Works
Chicago, Ill.

GEORGE S. MICAN

. . . . a new approach to metal flow theory is covered in this article . . . . the contour patterns developed under rolling or forging are shown to be related to the ratio of the height of stock worked to the horizontal component of the chord of the roll contact arc . . . .

▲ OBSERVATION of rolling operations brought to our attention the development of three typical vertical cross-sectional contour patterns in the course of rolling ingots into blooms, billets and slabs. The consistency of the development of these contours prompted a study of their significance. The contour pattern illustrated by Figure 1 is characterized by bulges below the horizontal boundaries merging into concavities as portions of the vertical boundaries. Vertical cross-sectional contours of this pattern will be referred to as "concave." The contour pattern illustrated by Figure 2 is characterized by the conversion of the original straight vertical boundaries into convex curves. Contours of this pattern will be designated as "convex," as their shape suggests. In some stages of reduction, very little distortion of straight vertical boundaries took place either toward the concave or toward the convex contours. Such contour patterns will be referred to as "undistorted."

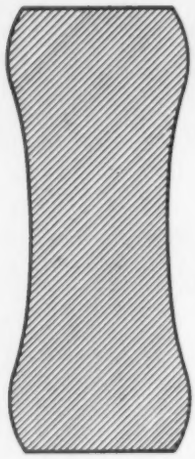
Following the foregoing, there were observations of forging operations which revealed the development of similar cross-sectional contour patterns in the course of forging ingots into blooms. At this point it was recognized that the ratio of height of stock worked to the effective width of the die employed was an apparent controlling factor in the development of contour patterns. A corresponding relationship was then recognized in rolling. The ratio of height of stock worked to the horizontal component of the chord of the arc of roll contact established the contour patterns. In subsequent discussion, this horizontal projection of the arc of roll contact will be considered the effective die width in rolling. For abbreviation, die width, in lieu of effective die width, will be used in connection with both rolling and forging.

It was determined that for equivalent heights of stock, vertical cross-section contour patterns for rolling and forging were similar when the die width in forging and the horizontal projection of the arc of roll contact in rolling were equal. In other words, for the same height of stock and the same die widths, the same vertical cross-section contour patterns developed in rolling and forging.

The critical ratios of stock height to die width which determined vertical contour patterns were found to be in a range from 1.8 to 1 up to 2.2 to 1. Observations and determinations covered a wide range of carbon and alloy steel grades, including 18.8 stainless. No steel grade observed developed other than a concave cross-sectional contour pattern when the stock height to die width ratio was greater than 2.2 to 1 through the reduction. No steel grade observed developed other than a convex contour pattern when the stock height to die width ratio was less than 1.8 to 1 through the reduction. Concave contour patterns not severely accentuated were converted into convex patterns when the reduction was carried through the critical ratio range. Undistorted as well as an overlap of concave and convex patterns developed in the critical ratio range.

It is recognized that composition of metal, deformation temperatures and deformation rates will affect the development of cross-sectional contours. It was observed in connection with the rolling of aluminum

Presented before AISE Annual Convention, Cleveland, Ohio, September 30, 1948



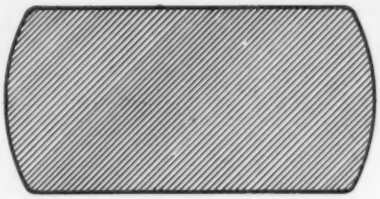


Figure 1 — (left) The vertical concave cross section contour is characteristic of a height to die width ratio greater than 2.2 to 1.

Figure 2 — (right) The vertical convex cross section contour is characteristic of a height to die width ratio less than 1.8 to 1.

at 750 F that the critical stock height to die width ratio approximated 0.8 to 1. In the rolling and the forging of steel in wide ranges of composition at common rolling and forging temperatures and at deformation rates varying from those of forge presses to those common to the bulk of primary and secondary mills, it was found that these factors were minor in contrast to the effect of the stock height to die width ratios on the development of cross-sectional contour patterns. Accordingly, effects of composition, temperature and deformation rate will not be discussed in detail. The discussion will be confined to the major factor, the effect of the stock height to die width ratio. In the interest of simplicity in subsequent discussion, the critical ratio for steel will be referred to as a 2 to 1 ratio.

When ingots are forged into blooms, the operation is a step forging process. The area and the mass between the dies is the only portion of a larger mass under direct compression. The compression incident to the rolling operation is a continuous process in which only that portion of the mass between and in contact with the rolls at any moment is under direct compression.

In order to determine whether the critical ratio was altered when an entire mass was subject to compression, cylinders and prisms were compressed between dies of larger cross-sectional areas than the stock. If the stock height to diameter ratio for cylinders exceeded a ratio of two, the vertical cross-sectional contour developed was concave. When the ratio was less than two, the contour developed was convex. When the stock height to minimum horizontal dimension ratio of a prism was greater than two, the vertical cross-sectional contour developed was concave. When the ratio was less than two, the contour developed was convex. Even though the dies were larger, in neither case could the effective die width be greater than the minimum horizontal dimension of the piece. The conclusion drawn was that the critical ratio of two, was effective in the development of vertical contour patterns regardless of whether the mass under compression was an integral unit or a portion of a larger mass.

Horizontal contour patterns, meaning those in the horizontal plane at the midpoint of stock height unless specifically defined as being otherwise, were initially investigated by the compression of prisms between large dies. The deformation of all prisms wholly contained between dies in the course of the deformation, developed plane patterns which progressed with continued deformation toward the circular shape as the final contour pattern. Three intermediate contour patterns were recognized (Figure 3), characterized by:

1. Equivalent spread in the four principal directions.
2. Differential spread and elongation bounded by continuous arcs.
3. Differential spread and elongation bounded by continuous arcs as short parameters and arcs plus straight lines as long parameters.

The relationship of spread to elongation was determined for a series of prisms and the results plotted. This relationship to the intermediate contours will be explained later.

When a mass of steel stock of square or rectangular cross-section is compressed between rectangular dies in a step forging operation, the prism under compression at any given time is only a portion of a larger mass. The prism under direct compression will, however, tend to develop the same horizontal contours as if it were an integral piece. The continuity of material between the prism under direct compression and the balance of the mass, will resist the trend for the contour pattern development equivalent to that of an integral piece. Such resistance will induce compressive stresses in the central areas of horizontal planes in the longitudinal direction, and tensile stresses in the edge areas.

It will be shown that:

1. For the same-size stock, step forged to a given thickness in one instance and rolled to the same thickness in another instance, the average spread and the total elongation will be practically equal if the die widths in the two instances are equal.
2. The relatively small difference in dimensional extensions which is found is attributable to the higher deformation rate in rolling and the differential speeds of roll surfaces and stock.

Since the vertical cross-sectional patterns are similar and the spread and the elongation in rolling and forging are practically equivalent under the conditions stated, it may be reasonable to assume that the induced stresses resulting from compression only, may also be practically equivalent.

It has been found by several plants possessing both blooming mills and heavy forging equipment that large blooms requiring complete freedom from center porosity could be produced only by forging. The conclusion has been generally accepted that the forging operation is therefore superior to rolling for interior quality. While the conclusion may generally be correct, it is correct by virtue of the size of the rolling and the forging equipment available and not by reason of any fundamental difference in the basic nature of the two operations.

For instance, one 3000-ton press installation has rectangular dies of a 14 in. width. It will therefore develop a convex vertical cross-sectional contour on a 28 in. square ingot at the start of forging operations. A primary mill with 40 in. rolls at 3 in. draft would have a die width of 7.6 in., the chord of the arc of roll contact. It would not tend to develop a convex vertical cross-sectional contour until a stock height of less than

15.2 in. was reached. It will be shown that convex contours are synonymous with the closing of axial voids while concave contours are not. It would require a mill with 72 in. rolls at 5½ in. draft to simulate the die width of the forge press cited. These considerations point to the conclusion that axial voids can be closed just as satisfactorily by rolling as by forging, provided that the stock height to die width ratios are equal.

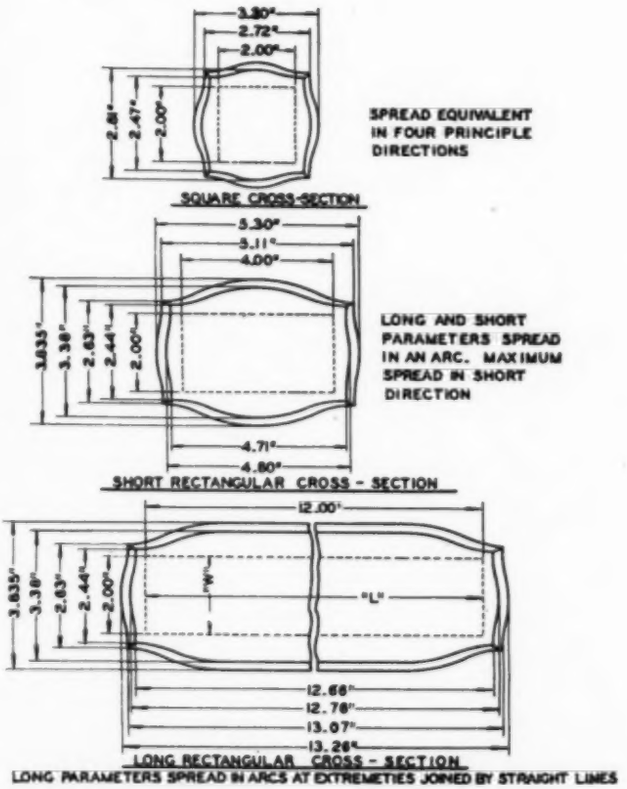
It is also a common experience in connection with the working of highly alloyed steels that they are less susceptible to surface breaks when forged than when rolled. It will again be brought out that relative stock height to die width ratios are major contributing factors in that the bulges of concave contours are more susceptible to induced stress concentrations than are the surface areas of undistorted or convex contours.

It will also be shown that steel rolled or forged is equally susceptible to the accentuation of surface seam opening and to the conversion of subsurface weaknesses into surface seams and breaks. The determinant for this condition is the character of metal flow in free spread. The restrictive to the development of this condition is the confinement of free lateral spread by shaped passes, or the restriction of its effects by intermittent edge work.

The tensile stresses induced in the surface of rolled material by virtue of differential speeds of stock and rolls, are not similarly induced in the forging operation. This is believed to be the major difference in the induction of stresses affecting quality, between the rolling and the forging operations. The surface tensile stresses induced in rolling can be held at minimum intensities by low rolling speeds.

A summary of the prior discussion may be stated to be the submission of the premise that when stock height to die width ratios are equal for stock of the same size, subjected to the same reduction in rolling and forging, cross-sectional contour patterns, metal-flow patterns, dimensional extensions, induced stresses and quality effects are substantially equal. The remainder of the discussion will consist of the presentation of additional evidence in connection with the stated premise.

Figure 3 — These horizontal contours were developed with a 50 per cent reduction of the specimens. All approach a circular contour when the deformation ratio $R = \frac{L}{W} \times 4$.



METAL FLOW

Since the distortion of original contours into various patterns is accomplished by reason of differential metal flow in the various portions of the cross-sections, it is necessary to comment briefly on the general aspects of metal flow. A vast amount of study has been expended on metal flow in cold deformation, which is considered deformation below recrystallization temperatures where grain deformations are substantially permanent when effected. Metal flow in cold plastic deformation, even in single crystals, is a complex process, predicated on block slippage along slip planes, accompanied by a tendency for the lamellae to rotate about an axis normal to the slip planes.

A mass of cold steel consists of innumerable grains of random orientation. When such a mass is subjected to progressively increased compressive loading, elastic deformation will occur first. Elastic deformation is believed to consist of distortion of the space lattices without slippage along the lattice planes. At the elastic limit stress, plastic deformation begins with the grains of most favorable orientation and progresses through all grains in the mass.

Hot deformation of steel, considered to be deformation at temperatures above the transformation range, is believed to be identical in basic mechanism with that of cold deformation, although largely indirect rather than direct evidence of this exists. Grains deformed at temperatures above the transformation range recrystallize so rapidly that even austenitic steels such as the stainless grades do not show grain distortion resulting from hot work when they are quenched immediately after working.

It is believed that the recrystallized grain size attained in austenitic steels immediately after hot working and quenching is related directly to the number of centers of nucleation and they in turn are the direct result of the grain fragmentation accomplished in hot working. Under controlled conditions, therefore, grain size in specific locations can be used as a qualitative measure of the amount of work imposed and the amount of metal flow that occurred in a series of austenitic steel samples. In carbon steels, hot-working effects are masked not only by the initial recrystallization but also by grain growth and by recrystallization through the transformation range.

Figures 4 to 9 represent Type 304 stainless test pieces turned to ½ in. diameter x 1¼ in. long, heated to

Figure 4 — 0 per cent reduction (1¼ in. height) A.S.T.M. grain size No. 1.

Figure 5 — 20 per cent reduction (1¼ to 1 in.) A.S.T.M. grain size No. 5.

Figure 6 — 40 per cent reduction (1¼ to ¾ in.) A.S.T.M. grain size No. 7.

2100 F in a muffle furnace and held at temperature for 20 minutes. No work was performed on the first test, it merely being quenched from the holding temperature. The remainder of the tests were successively upset by one hammer blow in increasing increments of ¼ in., with the final test being upset to a 3/16 in. thickness. Each test was water-quenched immediately after upsetting; all were cross-sectioned, polished, and etched in concentrated nitric acid; and the photomicrographs shown were taken at 500 magnification at each cross-section center. In these figures, magnification is 233X. A comparison of the figures illustrates the qualitative comparison which can be made as to the work done and the metal flow that occurred at the same locations in the respective tests.

Figure 10 is the last test of the prior series, showing the central portion of the cross-section at 100 magnification. The grain size at and immediately below the die contact surfaces shows very little work done and very little metal flow at those locations. Decreased grain size at progressively greater distances from the die contact surfaces shows greater deformation and more extensive metal flow until a central area of approximately uniform deformation and metal flow is reached.

If it were possible to divide the test piece into a multiplicity of theoretical disks and maintain the identity of the disks through deformation, a definite relationship would be found between the grain size, the final thickness, and the spread of any portion of one disk compared to another portion, as well as a corresponding relationship between the various disks. The pattern of metal flow could then be readily ascertained.

While the maintenance of the identity of theoretical disks in a solid is impractical, an approximation of the theoretical condition of infinite disks can be applied by building up cylinders from thin physical disks. If the behavior of such a "built-up" mass under load is the same as that of an equivalent solid, and the behavior of austenitic steels and carbon steels is the same, it seems reasonable to assume that the measurable effects afford a sound basis of study.

Identical cylindrical tests, of austenitic and carbon steels, were placed in compression; and it was observed that under the same conditions of stock height to diameter ratios, the cross-sectional contours developed in exactly the same manner. Similarly, cylindrical "built-up" and solid specimens of identical size, tested in compression under the same conditions, were alike and duplicated the contour patterns of the aforementioned grades. It was therefore believed that the same analysis of metal flow based on final disk thickness, spread, and location could be applied to carbon as well as to austenitic steels and to "built-up" as well as to solid sections.

A cylinder was built up to an 8 in. height from ½ in by 3 in. disks held in concentricity by a central pin. Figure 11 shows the cross-section of this cylinder after it was heated and compressed to a 6½ in. height. The concave cross-sectional contour pattern shown is characteristic of the deformation contour patterns when the height to diameter ratio exceeds 2 to 1. The maximum diameters of the component disks are attained in the bulge portions of the cross-section. The disks which attained the maximum diameters in the course of the deformation would be the path of least resistance to metal flow for the cylinder as a whole. They would therefore be the disks within which maximum deformation took place and would consequently be the disks of the least average thickness after deformation. Since they were the path of least resistance to metal flow, and sustained the maximum deformation and spread, their outer peripheries would lead the adjacent disks in lateral spread and would tend to pull the adjacent disks toward an equivalent spread through the medium of friction and adhesion.

Friction and adhesion will cause resistance to slippage in the disk junctions, although some slight slippage will occur. If at this point a greater multiplicity of disk junctions can be visualized between the physical junctions shown, and a slight amount of slippage can be conceived for each, the taper of the disk peripheries which form the bulge contour can partially be accounted for.

The disks in contact with the die surfaces are not deformed in thickness or in lateral spread to the same extent as the disks farther removed from those surfaces, by reason of the frictional resistance between the contact surfaces of the disks and the dies, and by reason of the fact that heat is abstracted more rapidly by the solid dies than heat is lost by radiation from the disks farther removed from the die contact surfaces.

When the cross-sectional contour of a compressed cylinder contains an area of uniform diameter in the

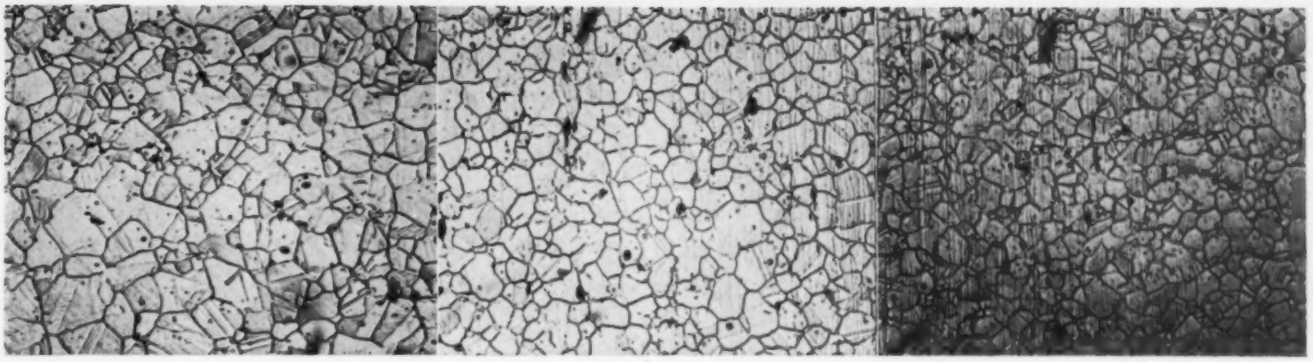


Figure 7 — 60 per cent reduction (1¼ to ½ in.) A.S.T.M. grain size No. 8.

Figure 8 — 80 per cent reduction (1¼ to ¼ in.) A.S.T.M. grain size No. 8.

Figure 9 — 85 per cent reduction (1¼ to 3/16 in.) A.S.T.M. grain size No. 9.

central portion, the condition may be designated as one of partial slip penetration in so far as all disks within that area will be deformed to the same thickness and will have spread to the same diameter.

When height to diameter ratios are less than 2 to 1, convex deformation patterns are developed as illustrated by Figure 12. This shows the cross-section of a 3 in. "built-up" disk cylinder, heated and compressed from a 6 to a 3 in. height. Under this condition the centrally located disks apparently are the path of least resistance to metal flow. It is evident in the illustration that they were subject to the maximum deformation, are deformed to the minimum average thickness and have spread to the maximum diameters.

These disks, being in the path of least resistance to metal flow, for the cylinder as a whole, will lead in spread in the same manner and with the same effects as described for the leading disks in the bulges of the concave contour. Since they are the leading disks in lateral spread, their outer portions will be the first portion of the cylinder to move outside of the area of direct compression which is equivalent to the area of the disk surface in die contact.

The manner in which a cylinder representing a single disk will deform is shown by Figure 13. This shows the deformation contour of a solid 3 in. original diameter cylinder, heated to 2200 F and compressed between two 3 in. diameter cold dies from an original 2 in. height to a ¾ in. web thickness. The pins shown were utilized as centering pins to maintain the cylinder in alignment with the dies during compression and may be disregarded. The periphery of the cylinder surface, which has been in contact with the die in the course of compression, shows an inverse curvature at the initial contact edges merging into an approximate straight line which makes a junction with that part of the surface which is still in contact with the die at the conclusion of the compressive stroke. The outer periphery of the cylinder developed into a convex contour. Additional tests showed that the angularity of the approximate straight line joining the edge periphery with the final die contact surfaces increased with increasing reductions. If one can visualize a physical horizontal line through the center of Figure 13, in order to simulate two disks, it can be seen that for both of the outer faces the contour from the periphery of initial to final die contact is an inclined curvature while the line of theoretical separation of the two parts is straight by reason of the restriction to spread of the adjacent disk.

The two central disks in the "built-up" cylinder in Figure 12 are not subject to completely free deformation outside of the area of direct compression as was the case in connection with Figure 13. As previously explained, in so far as the central disks are the leading disks in lateral spread, they tend to drag the adjacent disks toward an equivalent spread. Consequently, the adjacent disks in the mass moving outside of the area of direct compression constitute a restrictive to free spread of the central disks in the vertical direction. The result is that the angularity of a line, with some curvature, joining the disk edge to interior points, is reduced in contrast with the condition of free vertical spread. The angularity and curvature effects are additive in that each disk from the central to the die contact adds a corresponding effect.

The culmination of this progressive accumulation of effects on the die contact disk is to deform and spread the outer portions of the disk to a greater extent than the central portions. The curved deformation of the die contact disk in turn generates a reciprocal and intensifying effect in that it is converted into a curved surface instead of a straight surface die, and in its downward travel accentuates the deformation of the central portions of the intervening disks in contrast with the outer portions.

For the purpose of discussion of the bulges in concave contours, the ends in contact with the dies will be referred to as the far ends, and the inner extremities of the bulges as the near ends. The explanation of the bulge of the convex contour is applicable to the corresponding bulge portions of the concave contour, with the exception that the curved die contact disks are existent only at the far end of each bulge, by reason of the absence of die heat abstraction effects on the near ends of the bulges. The movement of the curved die disk from one end only, in continued deformation, tends to depress the center line of the bulges where reverse changes of curvature would be anticipated, and tends to straighten the disk junction lines in the near end portions of the bulges so that they approach the horizontal pattern of the intervening disks.

Progressive deformation of a similar cylinder to a 1½ in. height is illustrated by the cross-section shown

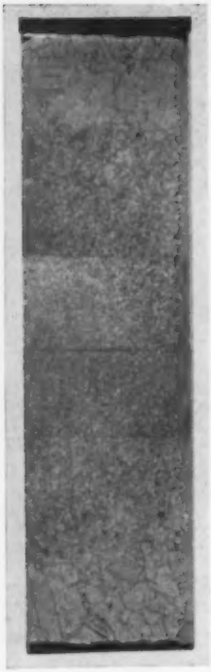


Figure 10 — 85 per cent reduction (1¼ to 3/16 in.). Note the grain size gradient from the periphery to the center. This illustration has a magnification of 100.

in Figure 14. The major development shown is the movement of several of the disk peripheries completely into the die contact surfaces. This movement trend was evident in the bulge portion of the concave contour and became more accentuated in the prior convex pattern. The mechanism of relative displacement of the disk junctions was explained in connection with the previous illustration.

Before the deformation, of any of the three cylinders, the horizontal surfaces of all disks were equidistant from the die surfaces. In the bulges of the concave contour, the outer edge of each disk moved toward the die contact surface in relation to more interior points on the disk surface. This trend was accentuated as shown in Figure 12 and culminated in the movement of a number of outer disk peripheries completely into the die contact surfaces as shown in Figure 14.

The mechanism of the movement has been explained, but induced stresses incident to the movement merit comment. A solid cylinder deformed identically with that shown in Figure 12, may be conceived to have a great multiplicity of theoretical disks which after deformation will follow the same contour patterns of

Figure 11 — A built up laminated 3 in. diameter disk cylinder has been compressed from 8 to 6½ in.

Figure 12. Since a slight slippage occurs between each disk junction, the surface metal spanning such junctions is subject to a tensile stress. If surface or subsurface weaknesses exist at these locations, the tendency is for them to open into horizontal seams. The resistance which may be anticipated when the disks move into the planes of the die surfaces is illustrated in Figure 14 by the openings between the disks at the peripheral corners. This also illustrates why surface and subsurface weaknesses tend to develop into edge seams on material subject to free spread under compression.

It is a common observation, when upset tests are made on cylinders, that subsurface weaknesses will develop into open vertical breaks when critical stresses for the outer fibers of the material are exceeded. The equivalent of the central disks of convex contours subject to the maximum spread of their outer peripheries, are most susceptible to the start of vertical cracks. Correspondingly, the equivalent of the disks of maximum spread of the concave contours are, likewise, most susceptible to the start of vertical cracks.

An analysis of metal flow has been considered by the utilization of integrated disk masses positioned in planes normal to the direction of the imposed compression. An analysis of metal flow and induced compressive and tensile stresses as related to internal defects, also can be made by a consideration of integrated disk masses positioned in planes parallel to the direction of the imposed compression. This is illustrated in Figure 15 from Siebel and shows the metal flow and stress distribution conditions which prevail when the height of stock to die width ratio is greater than 2 to 1.

The condition illustrated is in accentuated form, known in steel rolling-mill parlance as an "overroll." It is evident at the start of rolling operations when normal drafts are employed with roll diameter to stock height ratios of less than 4 to 1 on structural and forging-steel grades. When the overall contour is established in accentuated form in early stages, it may persist by inheritance even after roll diameter to stock height ratios exceed 4 to 1. The corresponding critical ratio for highly alloyed steels and aluminum is higher and varies for other metals.

Under certain conditions, such as in large ingots poured in open-top molds, voids at or near the central axis in the upper portion of the ingot are normal to the solidification of large masses of steel. When such large ingots are forged or rolled to large blooms, and in the entire reduction, stock height to die width ratio is greater than 2 to 1, or with normal drafts roll diameter to stock height ratio is less than 4 to 1, the induced interior tensile stresses will prevent the closing and welding of interior central voids. The foregoing is a fundamental cause for interior unsoundness even when the voids are free of segregates.

DEFORMATION IN HORIZONTAL CONTOURS

The fact that metal will tend to flow in the path of least resistance is a basic principle which is applicable to the flow patterns of horizontal as well as vertical contours. The explanation of the principle is simple in

connection with horizontal or plane contours in contrast to that required for vertical, which involves the subject of slip penetration (commonly referred to as work penetration). The latter subject is one which merits a paper in itself for its proper presentation.

Consider the specific example of a ⅜ in. cutting edge moving down into 6 x 6 in. billet stock (Figure 16). Consider a particle on the longitudinal axis of the piece just under the center of the cutting edge. It can be seen that the particle would need to move 3 in. in a transverse direction to be out of direct compression, while it would need to move only 3/16 in. in a longitudinal direction to be out of direct compression. Consequently, the longitudinal direction is the path of least resistance for the movement of the particle.

The foregoing principle is employed when a hammer drawing operation is resorted to. This merely implies the lengthening of a piece in a desired direction to a greater extent than would be possible by an equivalent reduction in thickness attained by the use of die widths normal to the hammer or press on which the work was performed. It implies the use of narrow tools in a direction transverse to that in which maximum

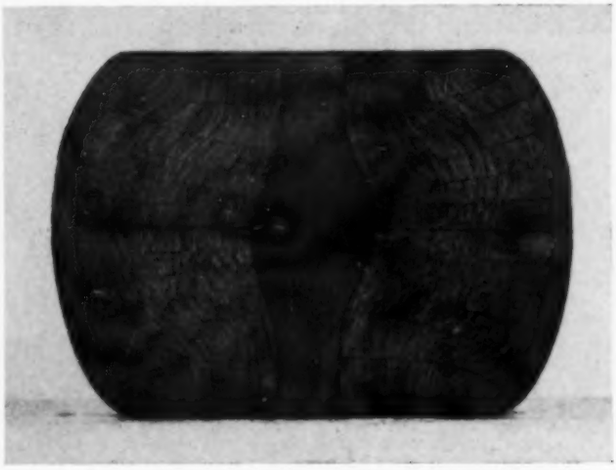


Figure 12 — This laminated 3 in. diameter disk cylinder was compressed from 6 to 3 in.

length is desired. Such use of narrow tools facilitates the flow of metal into the path of least resistance — the longitudinal direction.

Vertical cross-section contours of prisms after deformation respond to the ratio of height to minimum horizontal dimension in the same manner as cylinders do to the ratio of height to diameter. The lateral deformation spread of prisms of square horizontal cross-section, is equivalent in the four principal directions. (Figure 3). When the horizontal cross-section is a rectangle, the path of least resistance to spread is in the direction of the least dimension. Maximum spread will occur along the short axis with the long parameters moving out in an arc for low ratios of length to width. For high ratios of length to width, the deformation contours of the long parameters will be arcs at the extremities, joined by straight lines. The short axis spreads at a greater rate until at the approximate deformation ratio of $R = \frac{L}{W \times 4}$ determined by experiment, the short

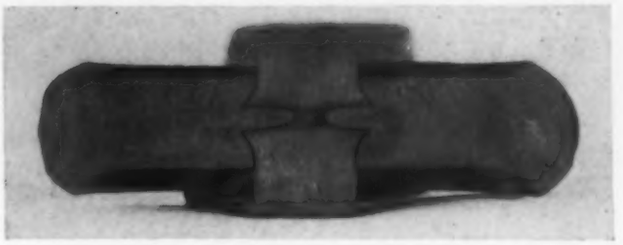


Figure 13 — This single disk was deformed by top and bottom dies whose diameter was equal to the original diameter of the cylinder.

and the long axes reach equivalence to form a circular contour. This is predicated on a starting height to width ratio of unity.

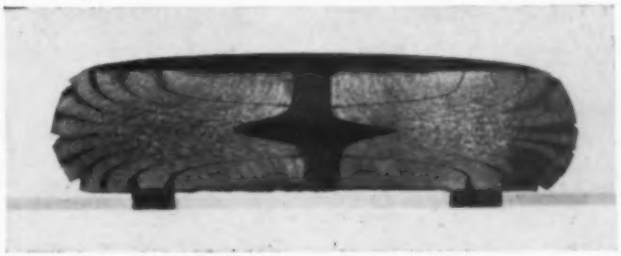
The relationship of elongation and spread was discussed qualitatively. Figure 17 (left) shows quantitative relationships for a series of 2 in. square key stock pieces cut into increased lengths by 1 in. increments and comcussed qualitatively. Figure 17 (left) shows quantitative relationships for a series of 2 in. square key stock pieces cut into increased lengths by 1 in. increments and compressed to 1 in. thicknesses. Figure 17 (right) shows the same series of tests reheated and further compressed to ½ in. thicknesses.

In this series of tests the 2 in. original dimension in all cases was regarded at the width, and linear extensions to this dimension were considered the spread. The varying original dimension, being 1 in. for the first test piece and 8 in. for the last test piece, was considered the length; and linear extensions to the length dimension were considered the elongations. In both instances the total elongation graph is a straight-line or a linear function of reduction and length. A straight-line graph for the elongation in connection with both series of tests merely means that elongation was a fixed amount for each piece with the same reduction, irrespective of the starting length. The exception to the foregoing occurs in connection with Test 1 by reason of the fact that the shortest dimension is at 90 degrees to the short dimension of other samples.

The transverse curve on the left of Figure 17 recorded in each case the lateral spread of the original 2 in. dimension in connection with all tests, and it should be noted that the transverse curve crosses the longitudinal graph at the 2 in. original length dimension. This substantiates the previous statement that in prisms of square cross-sections, lateral spread is equivalent in the four principal directions.

The transverse curve also shows that in all cases

Figure 14 — Note separation which occurs when the laminated 3 in. diameter disk cylinder is compressed from 6 to 1½ in.



where the 2 in. original width was the minimum horizontal dimension of the prism, spread was greater than elongation. The ratio of spread to elongation increased with increasing original lengths up to approximately the 6 in. length. This confirms the principle that metal will flow into the path of least resistance and that the contour of the long parameters of intermediate length to width ratio prisms when subjected to compression, will be arcs as shown in Figure 3.

Beyond the 6 in. length, or the length-to-width ratio of 3, the transverse curve tends to flatten out to a horizontal line, which merely verifies that for high ratios of length to width the long parameters of the prism will be partially straight lines, as shown in the bottom illustration of Figure 3.

The transverse curve on the right of Figure 17 shows equivalence of total transverse and longitudinal dimensions when the original 2 x 2 x 3 in. prism was compressed to a ½ in. thickness. This again verifies the statement made, that horizontal contours of rectangular prisms subjected to compression, will tend to approach a circular contour with increasing compression. As determined by experiment, approximate circular contours would be achieved when the reduction ratio from the original to the final thickness was equal to

$$\frac{L}{W \times 4.}$$

The contours developed for individual prisms when wholly compressed between dies cannot be duplicated in either shape or dimensional extensions by rolling the individual pieces. If such pieces were rolled even between extremely large rolls in either the longitudinal or the transverse direction, at no time in the rolling would die width be developed equivalent to the compression of the prisms wholly between large forge press dies.

Accordingly, it is necessary first to consider the deformation of equivalent prisms as portions of larger masses in step forging, and then to progress to the comparison of step forging with rolling when equivalent die widths can be imposed. If, under those conditions, the final dimensional extensions are practically equivalent, it seems possible to theorize logically on the comparisons of the behavior of the prisms as portions of larger masses in rolling and forging.

The illustration from Siebel, Figure 18, shows the manner in which metal will flow in a notched bar subjected to open step forging between narrow dies. As would be anticipated from the ratio of length to width shown for the original prisms defined by the notches, the sketch after forging shows greater elongation than spread. The closer the notch effect is carried to complete separation, the closer the segments approach the contours of individual like prisms. Whatever amount is retained as a solid junction would lie in the area of central horizontal compression, and the completion of the contour would be a straight line in lieu of a continuation of the bounding arc. The reason for this is indicated in the lower illustration of forging stress distribution in the horizontal plane, showing tensile stresses in the edge areas and compressive stresses in the central areas.

Figure 19 shows quantitative results of a test by R. E. Beynon on a 4 x 12 in. steel flat reduced from 2 to 1½ in. in thickness between a pair of 16 in. diameter rolls in one instance, and under a large forge press in the second instance. In the case of the rolled piece the average spread was 0.125 in., and the average elongation was 3.47 in. In the case of the forged piece the average spread was 0.78 in., and the average elongation was 0.563 in. Upon initial consideration this test would tend to disprove any theory of the equivalence for dimensional extensions in rolling and forging. However, in the case of the forged piece the effective die width ranged from 4 in. at the beginning of the compression to 4⅝ in. at the conclusion of the compression. On the other hand, the effective die width in the rolling operation may be determined as follows:

$$\text{Cosine } \alpha = \frac{7.75}{8} = 0.96875$$

$$\alpha = 14^\circ - 21' - 43''$$

$$\text{Sine } \alpha = 0.24803$$

Figure 15 — The formation of the concave shape during transverse forging corresponds to the axial stresses which are developed during the forging operation.

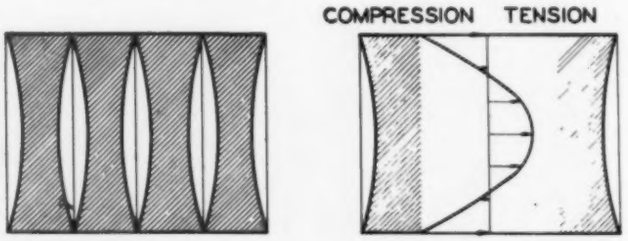
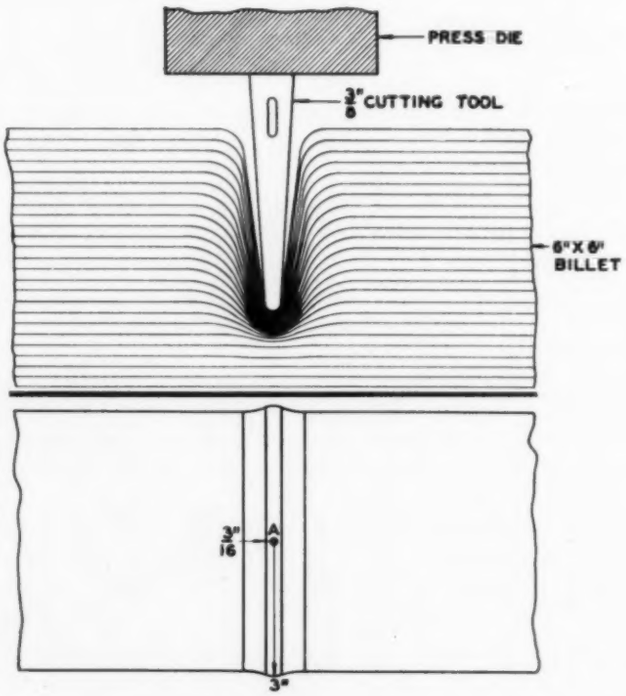


Figure 16 — On the top is shown the flow lines when a 6 x 6 in. hot billet is cut by a ⅜ in. cutting tool. On the bottom is a plan view illustrating the path of least resistance to metal flow.



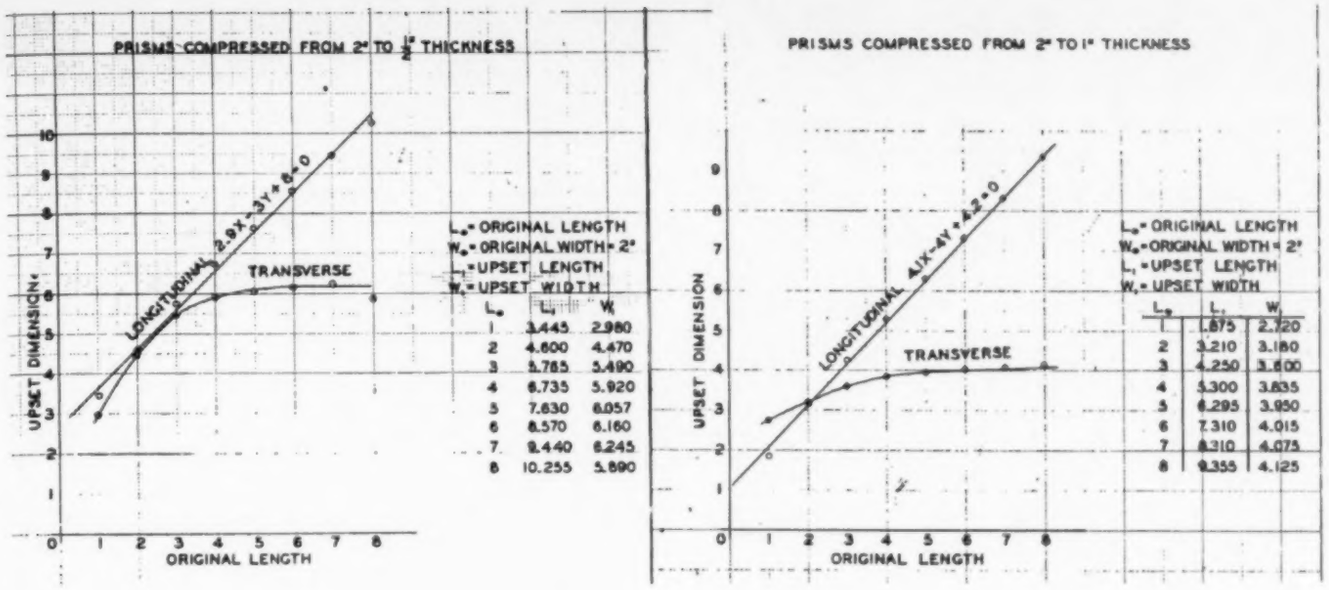


Figure 17 — Relation of upset length and width to original length.

Chord C = 0.24803 × 8 = 1.934 in. = Effective die width

A flat of the same size, 2 x 4 x 12 in., as that rolled in the prior example, was heated and forged by being fed between the dies of a press in approximate 2 in. length increments for each stroke. In this instance the effective die width was approximately 2 in., as in the rolling example. The piece was reduced, as in rolling, from a 2 to 1½ in. thickness. The approximate average deformed width was 4 3/16 in. The elongated length was 15 5/32 in. The elongation, therefore, was 3.15 in.; and the spread was 0.187 in. As will be noted, the spread and the elongation under these conditions approach practical equivalence with those attained in rolling.

The speed of deformation in rolling was greater than the speed of deformation in forging. Increased speeds of deformation accentuate flow of metal into the path of least resistance. There is also a tensile elongation attributable to the powered rolls in rolling. Since the test was not conducted on a laboratory basis, only the approximate effect of the foregoing two factors can be calculated, as follows:

Difference in elongations —
15.47 − 15.15 = 0.32 in.

Effect of speed and traction — $\frac{0.32}{3.47}$ = 9 per cent of total elongation

Balance of total elongation —
91 per cent = Effect of compression

If the piece step forged had been an integral piece instead of a notched bar, the edge tensile stresses would have been intensified to the extent of the relief provided by the opening of the notches in the course of deformation. Such intensification of edge tensile stresses would tend to flatten the curvature of the arc of lateral spread resulting from each press stroke and would make a continuous edge more nearly approach the straight line edges of rolled pieces.

If the notched bar had been rolled under the condition of an equivalent die width, the notches would have opened in the same manner as in the forged test. Observations indicate that the contours of edge crack indentations, where they occur in the rolling of thin sheets, can be related to the ratio of length and width of the prism under instantaneous direct compression of the rolls. Accordingly, if the final dimensional extensions and the intermediate conditions of stress and deformation are practically equivalent, it seems reasonable to assume that the relationship between integral prisms and corresponding prisms as parts of larger masses which exists in step forging, likewise exists in rolling though it cannot be physically demonstrated.

Practical application of some of the earlier comments is particularly evident in connection with the hot-rolling of sheet and strip product. The tensile stresses induced in the edges of the material subjected to repetitive reductions without sufficient relieving edge work are one of the fundamental contributing causes of cracked or broken edges. Edge breaks occur when the induced stresses exceed the tensile strength of the material at the rolling temperature. The induced compressive stresses in the central areas increase the rolling pressure on those areas, and in combination with the bending of the rolls are the basic cause of crown on hot-rolled sheet and strip.

DEFORMATION DIFFERENCE ROLLING VS. FORGING

Considerable evidence has been presented in behalf of the premise of practical equivalence of rolling and forging under the condition of equal stock height to die width ratios. Practical equivalence has been used in the sense indicated by the dimensional extension calcula-

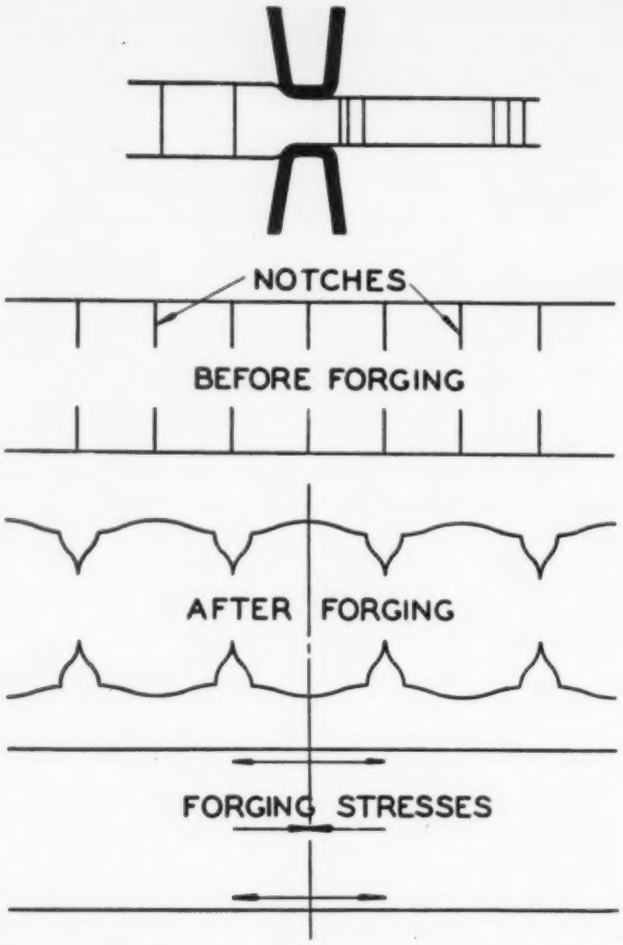


Figure 18 — Shown here is the metal flow occurring in a test of a notched bar which was drawn out by forging.

tion; a range of approximately 9 per cent from exact equivalence. To illustrate the differences that exist, the three basic components of the rolling operation, compression, extrusion, and tension necking will be discussed separately.

Figure 20A represents a pair of 40 in. diameter plain rolls, rigidly locked so that they cannot turn. The stock entered between the rolls up to their common vertical axis, represents a 25 x 30 x 90 in. plainwalled ingot entered on edge. It is assumed that the entire roll assembly embodies sufficient strength to compress the ingot 3 in. in the vertical direction. The deformation contours, the flow of metal and the trend toward stress concentrations will be predicated on the fact that:

$$\text{Cosine of angle } \alpha = \frac{18.5}{20} = 0.925 = \text{Cosine } 20° - 20'$$

$$\text{Sine } \alpha = 0.37999$$

$$\text{Chord C} = 0.37999 \times 20 = 7.6 \text{ in.} - \text{Effective die width}$$

$$\text{Ratio} = \frac{\text{Height of stock}}{\text{Die width}} = \frac{30}{7.6} = 3.94$$

Since the stock height to die width ratio is greater than two, the vertical cross-sectional contour would be concave. For the same reason, the deformed end of the vertical longitudinal cross-section contour would also be concave.

Maximum surface tensile stresses will be induced between points (A_2) on the maximum bulge protrusion and points (B) which were originally vertically below them at the base of the bulge. With respect to the latter, the points on the protrusion move in slip elongation and slip transverse spread. The intervening metal is subjected to tensile stresses; and if the bulge is accentuated, localized metal weaknesses may develop into open surface breaks.

Reference to Figure 15 and the related discussion establishes the fact that in the cross-sectional areas of the bulges, voids will tend to be closed by the induced internal compressive stresses in both the vertical and

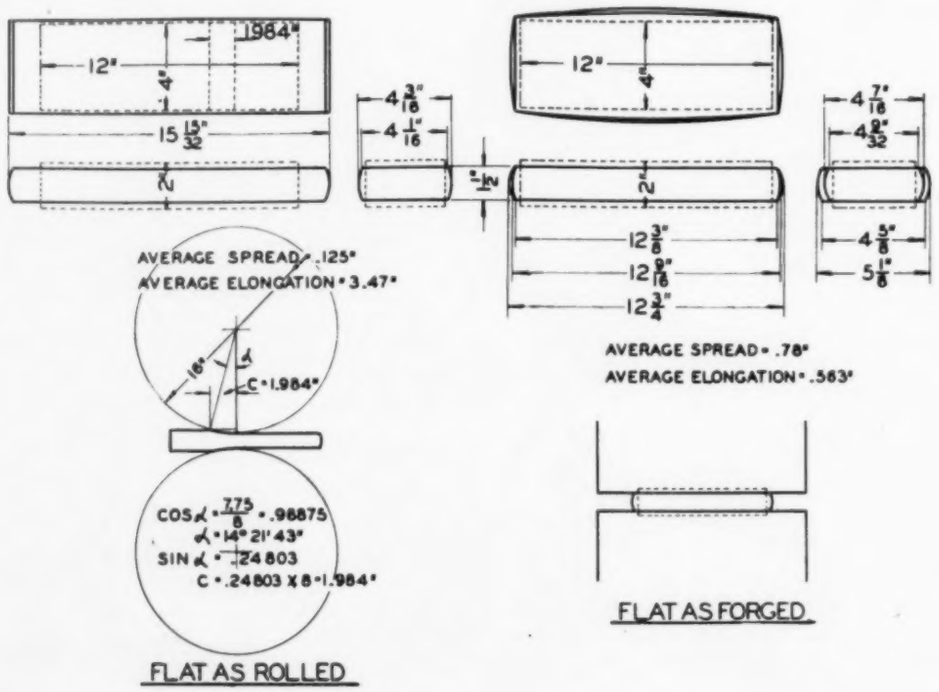


Figure 19 — On superficial analysis this comparison between rolled and forged flats would not indicate an equivalence of spread and elongation for the two operations. Practical equivalence resulted when the stock height to die width ratios were equal for the two operations.

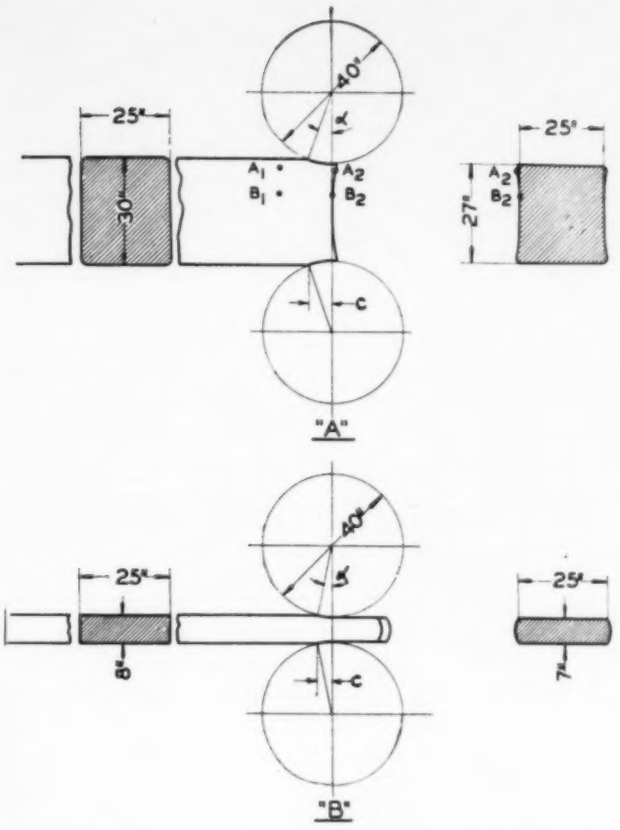


Figure 20 — A concave contour is the result of the rolling shown on the top (Figure 20A), whereas a convex contour results from the rolling of the slab shown at the bottom (Figure 20B).

the horizontal directions. Voids along the central axis and in the central areas will tend to be spread by the induced internal horizontal tensile stresses.

The area under direct compression in plan view is 7.6 x 25 in. Reference to the discussion of spread versus elongation will reveal that under the condition stated, metal flow into elongation will be greater than into spread and the end surface contour will be convex. This dimensional relationship also accounts for the accentuation of the concavity of the longitudinal cross-section and contour in contrast with the transverse.

If after the initial compression, a repetitive cycle of opening the rolls, moving the stock forward by a small increment, followed by closing the roll opening to the starting cycle setting were applied, the process would be a step forging operation with the horizontal chord of the arc of roll contact being the effective die width. Reference to Figure 18 (Notched Forge Test) and related discussion reveals that tensile stresses will be induced at the edges and in adjacent horizontal areas. If these stresses are accentuated by repeated compression without relieving edge work, corner failures may occur when the stresses exceed the tensile strength of the material.

For clarity at this point, a summarization of earlier data indicates that:

1. The basic patterns of metal flow in cylinders and prisms, "built-up" or solid, are similar under like prevailing conditions.

2. In prisms with unequal horizontal dimensions wholly compressed between dies, the metal flow and extensions were greatest in the path of least resistance, the short dimension.

3. Disk movements into die contact surfaces were more pronounced in the transverse than in the longitudinal direction on prisms of unequal horizontal dimensions.

4. The foregoing facts apply to prisms when they are under momentary compression as portions of larger masses in step forging and rolling as verified by final dimensional extensions.

5. With an understanding of these premises the general flow patterns of rolled and step forged sections can be approximately forecast.

Figure 20B represents an 8 x 25 in. slab with squared ends and edges, reduced at one end to a 7 in. thickness under the same conditions that prevailed in connection with the prior example. In this instance:

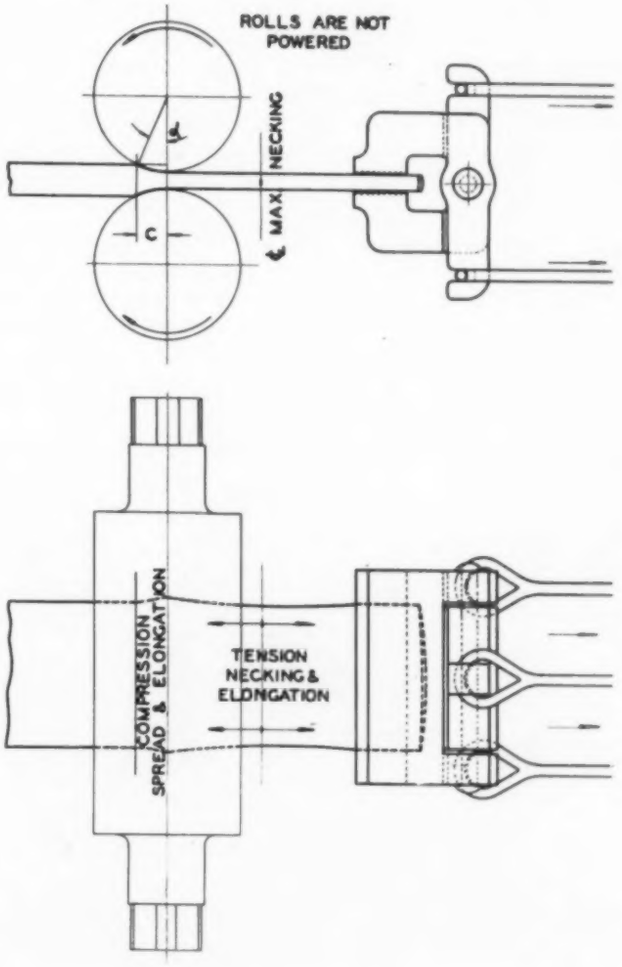
$$\text{Cosine of angle } \alpha = \frac{19.5}{20} = \text{Cosine } 12° - 50'$$

$$\text{Sine } \alpha = 0.22211$$

$$\text{Chord C} = 0.22211 \times 20$$

$$= 4.44 \text{ in.} = \text{Effective die width}$$

Figure 21 — The tension pull provided by the powered rolls, which act in the arc of contact, create a necking effect which tends to counteract the lateral spread which occurs due to the compression between the rolls.



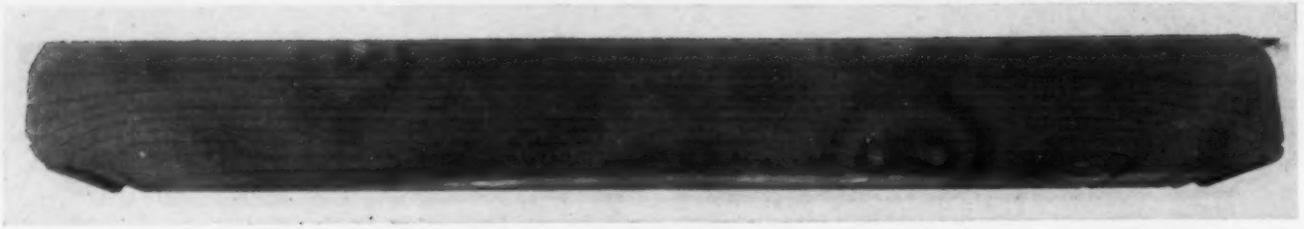


Figure 22 — A laminated bloom was rolled into a 1 in. thick plate on a 30 in. universal plate mill with free spread allowed.

$$\text{Ratio} = \frac{\text{Height of stock}}{\text{Die width}} = \frac{8}{4.44} = 1.8$$

Since the stock height to die width ratio is slightly under two, the cross-sectional contour will approximate the contour of Figure 12. By reference to Figure 12, illustrating the deformation of 2 to 1 ratio cylinders, details of metal flow with transverse and end contours can be determined by the application of the same reasoning utilized in connection with the prior example. In order to avoid repetition, comments will be confined to three essential differences.

In plan view the area under direct compression is now 4.44 x 25 in. Consequently, the trend of metal flow into elongation versus spread will under the same relative reductions, be greater in the current instance than in the prior example. It also then follows that for the same relative reductions, edge tensile stresses will be accentuated.

At and near the 2 to 1 stock height to die width ratio, points on the vertical edge, corresponding to A_1 and B_1 of the prior example, initially in vertical straight line relationship, move together with little or no longitudinal or transverse displacement. Consequently, under this condition, the tensile stresses in the surface material of the vertical edge originating from this source, will be minimized or eliminated. If the compression ratio, as defined, reaches low values as illustrated by Figure 14, the stress relationship between corresponding points on the edge surface will undergo further alteration. This was explained in connection with Figure 14 in relation to the potential development of horizontal seams from surface and subsurface weaknesses.

When stock height to die width ratios are less than two and a convex contour is produced as in the current example, the central axis and the adjacent central area are subject to both vertical and horizontal compression stresses. Under this condition, voids in the central portion of the mass will tend to close.This is an important distinction in connection with center porosity of rolled product and in relation to the conditions which produce a concave contour.

In connection with both of the prior examples, the fact that the first compression was made on a flat surface with curved dies is of negligible consequence in the total net result. If the compression cycle had been continued as outlined for the full length of the piece, it would have been the equivalent of a step forging operation. It can therefore be concluded that at the same deformation rates, the compression component of the rolling operation is the exact equivalent of a step forging operation to the same reduction, with die widths equal to the horizontal component of the chord of the arc of roll contact.

After the initial "end" compression, either the ingot in Figure 20A or the bloom in Figure 20B can be conceived to be pushed through the stationary rolls by a heavy ram. The opening between the rolls will be the equivalent of the die aperture in the extrusion process. Metal flow will be retarded, and tensile stresses will be induced in the material at the roll contact surfaces owing to frictional resistance.

After the material in each instance had partially protruded through the roll opening, it can again be conceived that heavy draw-heads can grip the material

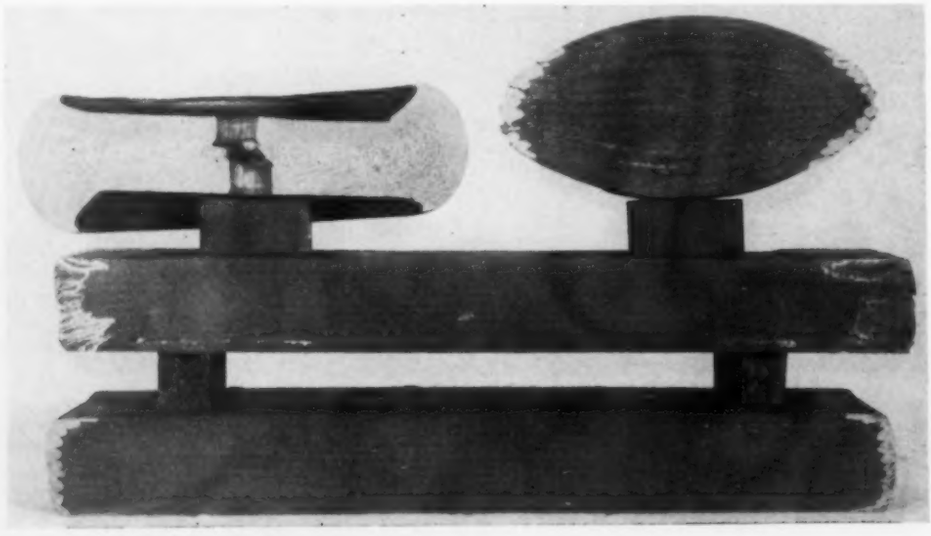


Figure 23 — The lower plate is a section of the welded portion of a laminated slab rolled to a 1 in. thickness and restricted to ½ in. lateral spread by vertical rolls. The upper plate is an unwelded section of the same reduced slab. At the upper right is shown an oval rolled from a laminated square billet. At the upper left is a single disk which was deformed by top and bottom dies whose dimensions were equal to the original diameter of the disk.

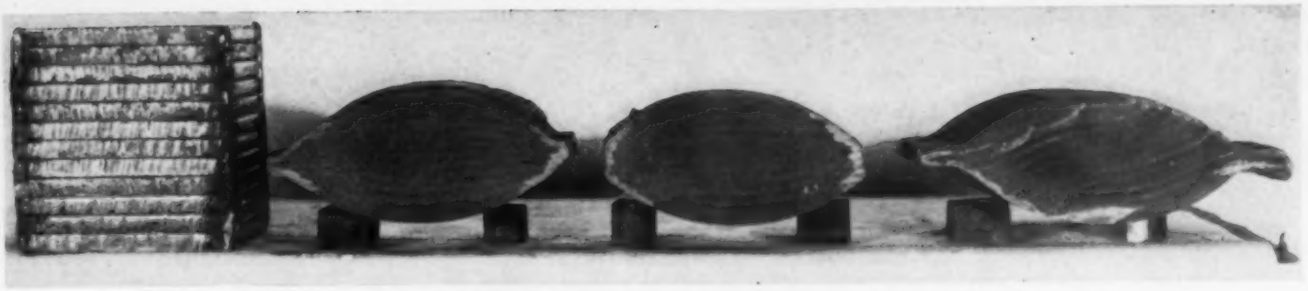


Figure 24 — Showing sections of an oval rolled from a laminated square billet.

and by the draw-head moving away from the rolls, the process will be converted into a hot-drawing operation. In addition to the major portion of the tensile stress due to frictional resistance which will remain, additional tensile stresses will be induced similar to those induced in a specimen pulled hot in a tensile machine. Necking will occur, and the greatest degree of necking will take place in the greatest linear dimension.

With the draw-heads still in motion, the brakes may be considered to be released (Figure 21) and the rolls permitted to revolve by the movement of the material drawn between them. In the arc of contact, there is only one point on the roll periphery at which the speed is equivalent to the speed of the material. On the entry side of this point the roll speed is greater than the material speed. On the delivery side of this point the material speed is greater than the roll speed. Tension stresses due to frictional resistance will still be induced. The tension stresses and the necking effects due to the draw-head pull will still be induced in reduced proportions.

The draw-heads may now be considered to be released and power applied to the rolls. The one-point coincidence of roll and material speeds will still exist. The tension stresses due to frictional resistance will, therefore, also exist. The tension pull previously supplied by the draw-heads is merely supplanted by the tension pull of the powered rolls acting in the arc of contact. The necking effect of this tension tends to counteract the lateral spread of direct compression. It is one of the two major factors determining the comparatively lesser net spread of wide flat sections in contrast with narrower sections.

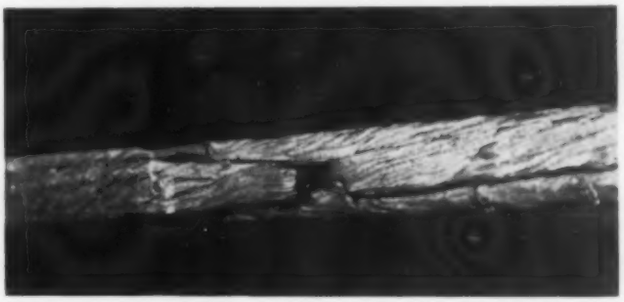
It is recognized that the foregoing statement does not conform with the current theory based on the increased frictional resistance in connection with wider widths between the roll surfaces and stock, and the consequent increased retardation of movement of the surface material in a transverse direction.

In the rolling of wide plates without edge work in the course of the reduction, maximum rolled widths are attained at the junctions of the deformed front and back ends with the edges. This is due to the fact that while necking cannot be operative on free ends, it is operative in the intervening length between the ends. Its effect increases with increasing widths. It is the second major determining factor mentioned in a prior paragraph. It is believed that the evidence on the subject favors the concept presented.

Inherently higher deformation rates and necking effects account for the slightly greater elongations (9 per cent) and lesser spreads attained in rolling as compared with step forging under the same die width conditions. Slower rolling speeds tend to achieve closer equivalence in dimensional extensions. Surface tensile stresses induced by reason of friction between the roll faces and the stock may result in surface breaks when steels of critical compositions are rolled and when the stresses exceed the tensile strength of the material at the rolling temperature. When rolling material of critical composition, slow rolling speeds are beneficial if they are not offset by excessive radiation losses in providing greater time for the deformation, consistent with the drafts used. The dimensional extension difference and the potential quality difference in connection with a very small percentage of steel compositions, represent the difference between practical

Figure 25 — The laminated plate shown was rolled on a continuous plate mill and edge tensile breaks occurred.

Figure 26 — The photograph gives an enlarged view of a tensile break shown in Figure 25.



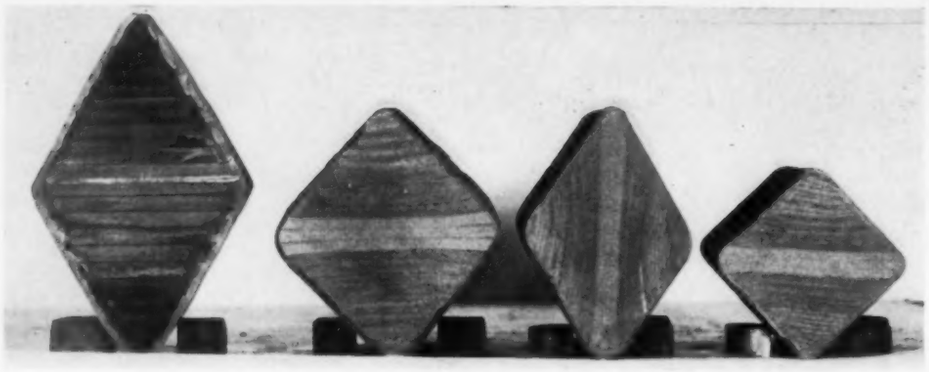


Figure 27 — Laminated diamond billet rolled into a square.

and exact equivalence of the rolling and the forging operations when stock height to die width ratios are equal.

ROLLING ILLUSTRATIONS

Figure 22 shows a cross-section of a 1 x 10½ in. laminated plate rolled from a 6 in. thick x 8¼ in. wide bloom on a 30 in. universal plate mill without the use of the vertical rolls in order to allow free spread. The bloom was fabricated from twelve ½ x 8¼ x 70 in. long plates welded along the joints at the ends and the sides to leave only a short central unwelded area. The bottom side of the plate, as shown, was the cold side of the bloom as delivered from the furnace. The bottom plate virtually had no transverse spread, whereas some of the center plates spread 2¼ in. The edge peripheries of three of the bottom plates moved into the bottom surface. This illustrates how edge defects can move into the surface in rolling just as in forgings and how they move preferably to the cold side. The openings between the plates as they move into the roll contact surface illustrate the tension induced at that point. This is identical to the observation made with deformed cylinders.

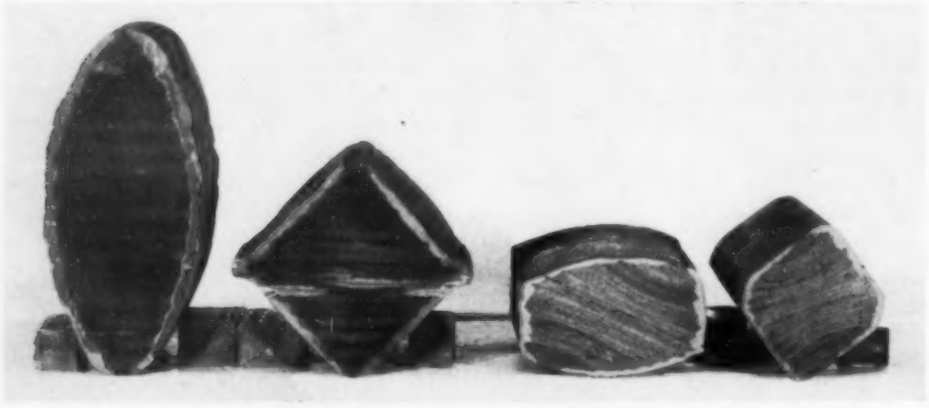
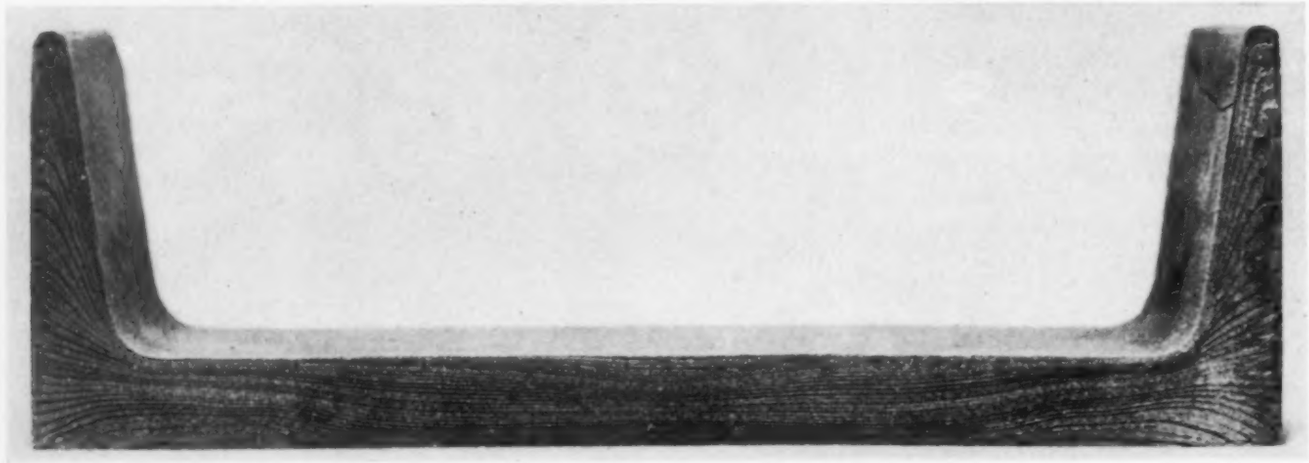


Figure 28 — The metal flow when rolling an oval into a square is shown by the deformations of the individual disks.

The next illustration, Figure 23 shows one welded cross-section and one unwelded cross-section of the same sized bloom rolled into the same thickness as in the prior example. The vertical rolls were utilized to permit only a ½ in. spread. It is evident that the move-

Figure 29 — Laminated billet rolled into an 8 in. channel



ment of the disk peripheries into the roll contact surfaces was more restricted than in the case of free lateral spread. A greater restriction to free spread could be imposed by the use of tongue and groove passes. The two seams along the upper left edge of the lower plate cross-section illustrate the conversion of sub-surface weaknesses into longitudinal edge seams since the breaks progressed through the weld metal. The basic pattern of metal flow with intervening disks moving into the roll contact surfaces is similar to that of cylinders deformed into convex contours.

The conversion of weaknesses into longitudinal seams is more clearly illustrated in the cross-section of the laminated oval. A 3 in. square billet was composed of twelve ¼ in. plates 70 in. long, with the joints welded at the ends and along the sides, leaving only a short unwelded central section. The billet was rolled through the oval pass at approximately 2200 F. Examination of the thickness of the disks shows that maximum compression and metal flow occurred at points approximating the initial location of the sides of the square in the pass. Free lateral spread occurred from the initial position of the sides of the billet in the pass to the outer confines of the pass. The numerous breaks through the weld metal, which constituted longitudinal seams on the surface, again illustrate the conversion of subsurface weaknesses into longitudinal surface seams.

The cross-section of the disk shown, merely illustrates metal flow under compression by flow lines when the top and the bottom dies are equal in diameter to the starting diameter of the disk.

The billet previously referred to, turned in the pass as the unwelded portion went through the pass. The next illustration, Figure 24, shows cross-sections of the initial billet, an overfilled section near the center and a cut of the unwelded turned-over portion.

Figure 25 illustrates typical "hot tensile" edge breaks occurring in a laminated slab reduced in three unidirectional passes from a 6 to a 1½ in. thickness without edge work. The tensile strain condition was accentuated by a colder bottom than top surface temperature of the slab as delivered from a continuous furnace. The slab was fabricated from twelve ½ in. thick plates. Note the necking down of the individual plates in the break and the V-type depth characteristic illustrated in more detail in Figure 26.

The next illustration, Figure 27, shows a laminated diamond starting billet rolled, without turning into a square in the first pass, into a diamond in the second pass, turned 90 degrees and rolled into a square in the third pass. A question pertaining to the merits of the square to oval formation versus the square to diamond formation is often asked. The answer to the question is relative. If product quality is satisfactory, the square to oval formation is preferable in so far as higher reductions per pass can be taken and higher producing rates can be attained. If longitudinal seams resulting from free spread are a quality problem, the square to diamond formation is preferable. A comparison and analysis of the two illustrations will show that the diamond formation is less severe than the oval with respect to the condition of free spread.

Only the first pass in the next illustration, Figure 28, has significance. It illustrates the fact that in the oval formation, severe lateral spread effects are confined to the square to oval pass and are moderate in the oval to square pass.

The next illustration, Figure 29, submitted as a matter of interest without attempting to provide a detailed explanation of metal flow, shows a cross-section of a standard 8 in. channel rolled from a laminated bloom. It was fabricated from structural-grade plates to form a bloom 6½ in. wide, 8½ in. high and 150 in. long. It was rolled through 10 passes on a cross-country type,

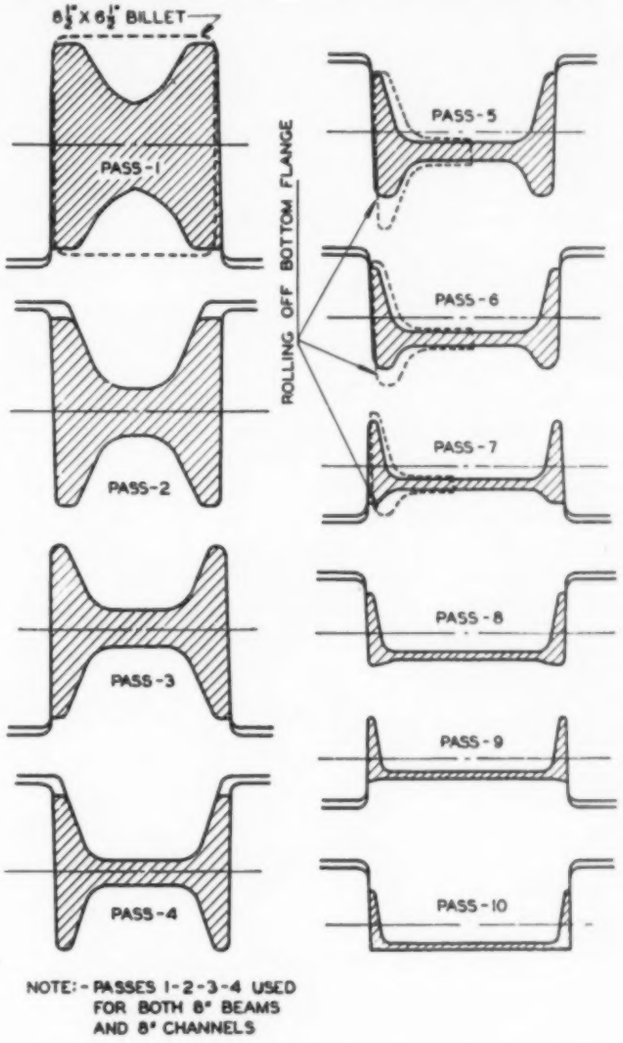


Figure 30 — Pass schedule for rolling the laminated billet into a channel is given by this series of sketches.

22 in. structural mill consisting of 8 stands, the pass formation being as shown in Figure 30.

The tests which were conducted in connection with this investigation were not conducted on a laboratory basis, and no claim for laboratory exactness is made for the results. It is recognized that this presentation is only a beginning in a phase of investigation that merits more exactitude and thoroughness of coverage so that a broader and more thorough knowledge of the rolling operation may permit rolling mill operators to improve such qualities of rolled product as are affected by the rolling operation, without increasing the costs to the producer or the consumer.

An Analysis of Maintenance Costs

. . . . minimum maintenance costs are dependent on cooperation between the operating and maintenance departments, as well as detailed knowledge of the factors entering into these costs . . . .

By LUKE TUNNY, Superintendent
Steel Producing Maintenance Department
Carnegie-Illinois Steel Corp.
South Works
Chicago, Ill.

▲ THE purpose of this paper is to discuss factors that contribute to the cost of maintenance and which, if controlled, will reduce this cost, and the maintenance cost per ton.

Too often we are concerned with total maintenance costs and do not break down expenses to their causes so as to concentrate corrective efforts on that portion which is most readily controlled. The maintenance man, to attain ultimate engineering control of maintenance costs, must have in his possession two basic types of information. First, he must know *where* the the maintenance money is being spent. Secondly, and equally important, he must know *why* the money is being spent, that is, what created the need for these maintenance expenditures.

Basically, over-all maintenance costs per ton can be reduced by only three methods:

1. By increasing equipment productivity.
2. By reducing the cost of individual jobs.
3. By reducing the number of jobs.

FACTORS IN INCREASING EQUIPMENT PRODUCTIVITY

By increasing the productivity of equipment we can reduce the maintenance cost per ton of product because the divisor is greater. This method is not under the control of the maintenance man, but either under the jurisdiction of the production man or involves capital expenditures and engineering redesign. Two factors must be considered:

Utilization of present equipment — What is the operating performance (productivity) of present equipment? If all operating performances were brought to 100 per-cent, what effect would this have on over-all plant maintenance costs?

Major design change considerations—How much could maintenance costs be reduced if all the plant's tonnage could be produced on the most modern low-cost unit and most modern plant layout?

FACTORS IN REDUCING THE COST OF INDIVIDUAL JOBS

Reducing the cost of individual maintenance jobs is a maintenance cost reduction method which is largely within the control of the maintenance man. There are many points at which job costs can be reduced and some of the factors to be considered are as follows:

Man hour performance of maintenance labor—What is the present man hour performance of shop labor, of field or bull gangs, of operating or station maintenance crews? How much of the inefficiency, if such is indicated, is due to low productivity of the tradesman himself and how much is due to poor planning and scheduling?

Shop practice—How efficient is present shop practice? Is the right machine or talent group always used? Is proper utilization being made of jigs, templets and fixtures? Are facilities utilized on a three turn basis? Are "rough" stock sizes rigidly controlled? Is spoiled work kept within reasonable limits?

Field practice—Are field jobs properly planned and coordinated? Have jobs been reduced to a standard practice basis wherever possible?

Shop layout, tooling and talent groups—Do the shops have the proper tools in the proper ratios? Is the existing shop layout conducive to efficient work? Is the correct mix of tradesman talents maintained and is provision made for properly trained replacements?

Shop overhead labor—What is the efficiency of supervision, clerical and indirect labor groups? Have specified workman to overhead ratios been developed? Is there the correct balance between overhead labor of a supervisory nature and overhead labor of a technical or engineering nature?

Usage of shop supplies and materials—Have shop foremen set up proper controls and educated their men in the efficient use of tools, supplies and materials?

Presented before AISE Chicago District Section Meeting, April 6, 1948

Have tradesmen been trained to properly operate machine tools, thus keeping cost of repair and maintenance of shop facilities at a minimum? Is material (shop stock) cutting practice controlled so that a minimum loss occurs from side scrap, short ends and odd sizes? Is shop material indentified at all times so that expensive misapplications do not occur?

Overall planning considerations—Are the principles of central planning and spares control being effectively utilized? Has a definite material procurement procedure been established? Is all work, both shop and field, planned and scheduled? Is the amount of "in-process" work in the shops rigidly controlled? Have jobs been analyzed for outside purchase cost vs. "plant manufacture" cost?

FACTORS TO REDUCE UNNECESSARY WORK

Preventive maintenance—This includes any initial design changes or installations made specifically to reduce future repair and maintenance costs and any maintenance work performed on a definite reconditioning or overhaul schedule. This type of maintenance is good practice; however, an economic critical between preventive maintenance and repair maintenance should be determined, as in the following examples:

1. Installing improved lubrication system in anticipation of reducing future maintenance costs through better lubrication.
2. Cases where experience shows that it is good practice to remove motors, complicated mechanism, etc. from service for periodic checking and overhauling before actual failure occurs.

Improper design—This includes all failures due to parts being improperly designed to perform the functions which they are currently required to perform. Such failures may occur repeatedly under normal operating conditions or may be caused by subjecting the equipment to rolling practices, etc., which were not intended when the equipment was originally designed, but which have now become the practice because of operating policies established by management. Problems of this type are the joint responsibility of the engineering and maintenance groups.—For example:

1. A drive shaft breaks repeatedly under normal operating conditions, indicating that the part has not been designed strong enough to perform the job satisfactorily.
2. A temper mill designed to temper roll sheets of 3/16 in. thickness and lighter is now used to temper roll light plate up to 3/8 in. thickness.

Improper lubrication—This includes all failures where parts fail to meet life expectancy standards due to insufficient or improper lubrication. Corrective measures may require better employee training, improved lubrication systems, improved type of lubricant, etc.

1. A bearing, after failure, is found to be badly pitted and scored, indicating insufficient lubrication.
2. A series of inacessible lubrication points are showing repeated failures due to poor lubrication, indicating a need for an automatic system.
3. A gear reduction system fails due to faulty judgment in replacing the lubricant formerly used.

Improper deferment of repairs—This includes all repairs made necessary as a result of failure to detect or recognize the need for maintenance at the proper time, or the failure to perform necessary maintenance after the need for such maintenance has become evident. This includes avoidable items only and does not include the "good practice" necessary deferment which is inherent in periods of extended high activity. Corrective measures may require better inspector training, improved preventive maintenance scheduling, etc. For example:

1. Painting of a corrugated sheet steel building is deferred until sheets are so badly corroded they must be replaced.
2. Postponing a furnace repair so long that a small patch job grows into a major furnace failure.
3. Improper operation of slow-down limit switches on gravity pit covers causes damage to the covers and to the upper edge of the pit as a result of shock created when the cover reaches the end of its closing traverse.

Normal deterioration — This includes all repairs made necessary by part failures after the parts have fulfilled their standard life or service expectancies.

Use of defective materials or substandard workmanship—This includes all failures which may result from the use of defective materials or sub-quality workmanship. Corrective measures would involve better quality control at shop and purchase points.

1. A cast steel part, after breaking, is found to have been improperly heat treated prior to original installation.
2. A gear, after failing, is found to be off tolerance and improperly keyed to the shaft.
3. An open hearth furnace bottom requiring excessive maintenance is found to be due to carelessness and improper bottom maintenance.
4. Improperly lined entry and delivery tables causes section in process to bend downward so that it creates a hammering action against the table rolls as it passes through the mill.
5. Improper installation of nozzle wells in steel ladles or care of ladle refractories results in ladle breakouts with loss of steel and damage to ladle shell and other equipment.

Abuse of equipment—This includes all repairs made

This 250 hp d-c motor on a mill drive was badly damaged in an overspeed wreck. Such wrecks can often be prevented with proper operating and maintenance procedures.

necessary by virtue of harmful, avoidable, acts committed by equipment operators.

Such abuse is over and above any machine damage which may be inherent in the "going" operating policy which management has established for the equipment. Of all the factors contributing to maintenance costs, abuse of equipment has the least reason for being permitted to exist and is the most easily and economically eliminated, since it requires only the enforcement of existing rules and regulations to prevent its occurrence. How much of the maintenance cost is due to equipment abuse is not determinable but we do know that careless handling of equipment is prevalent and must be minimized. It is certainly sufficient to cause concern and warrant a concerted effort to increase the efficiency of the operating and maintenance forces in regard to equipment care. Abuse of equipment over an extended period or in a specific instance, not only requires the incurrence of added maintenance expense but also results in slow downs and delays to operating equipment. The need for eliminating abuse has been recognized by management and an effort has been made to reduce it, but organized effort, with complete backing and follow-through, is needed to get maximum results. Examples:

1. Making side pulls with overhead cranes.
2. Rolling "cold" steel.
3. Overloading mill tractors.
4. Dropping ingots on mill approach tables.
5. Improper firing rates and erratically operated reversing control on open hearth furnaces present opportunities for deterioration of furnace refractories.
6. Overloaded or improperly loaded charging boxes are often jammed through door openings with resulting damage to doors and door frames.
7. Piling or bumping ingots against soaking pit binders results in damage to brickwork and binders.
8. Failure to run off slag at sufficiently frequent intervals to properly maintain pit bottoms. This allows slag level to build up to the point where there is a possibility of its cutting through the bridge wall and running into the checkerwork, resulting in damage and loss of efficiency in the regenerative system.
9. Careless removal of clay hot tops at the strippers results in an excess of refractory adhering to the ingots. After these ingots are charged into the soaking pits, the refractory freezes to the walls and tears out portions of brickwork when the ingots are lifted.
10. Failure to properly seal the soaking pit cover edges allows flame to seep out, with the result that the cover shoes heat up and burn.
11. Making electronic type recording and control devices inoperative, such as blanking off a portion of the aperture through which the electronic eye picks up impulses for temperature recording meters.
12. Lowering top roll while section of steel is in the pass. This forging action causes excessive strains on the screw-down mechanism.
13. Using manipulators for gagging purposes, especially when the manipulators are allowed to jam against the section being handled.

EQUIPMENT DAMAGE REPORT

No._____ Date: _____

Supt. _____ Time: _____

The following damage occurred to:

Equipment Involved: _____

_____

Estimated Cost of Repairs: $_____

Material: $_____

Labor: $_____

(Signed) _____ Date: _____
Maintenance Foreman

(Forward to Operating Foreman) _____

Cause of Damage: _____

_____

_____

Operator Involved: _____

Responsibility: _____

_____

Corrective Action Recommended: _____

_____

_____

(Signed) _____ Date: _____
Operating Foreman

(Forward to Operating Supt.) _____

Disposition: _____

_____

(Signed) _____ Date: _____

(Forward to Maintenance Supt.)

The Equipment Damage Report provides a means of informing both the maintenance and operating departments of the cause of damage so that combined action may be taken to prevent recurrence.

14. Allowing large masses of hot sections to remain stationary on table rolls for long periods so that these rolls become distorted and bent from the uneven heating.
15. Overloading and careless or inexpert handling causes much damage to cranes and charging machines. Such handling includes unnecessary plugging of drives, running through limit stops, pulling too many cars with charging machines, running for long periods of time on intermediate control points, resulting in damage to resistors and wiring.
16. Damage to magnets by bumping and by handling excessively hot materials and damage to magnet wires and hoist cables by entanglement, kinking and snagging.

A PLAN FOR REDUCING MAINTENANCE WORK

Much can be accomplished in reducing maintenance costs if an effective plan for the reduction in the number of maintenance jobs can be adopted and vigorously applied. Such a plan should be based on the following points:

1. The reporting of all damage or failures due to improper design, improper lubrication, improper deferment of repairs, defective materials and workmanship, and abuse of equipment, and the reporting of all abuse practices or improper operations before serious damage occurs so that the persons concerned may be fully aware of their existance and, therefore, be in a position to take the necessary

corrective action. All damage to equipment, when not caused by normal wear and deterioration, should be reported to the operating superintendent immediately after discovery of the damage.

2. Placing the responsibility for control of these factors in the hands of the supervisors in direct charge of the equipment operations.
3. Full investigation of all cases of damage including the placing of responsibility and the recommendation of corrective action.
4. Vigorous and consistent corrective action including discipline, training and correction of operating practices.

The report should be composed of three sections. The first section, filled in by the maintenance foreman, should show the date and time of the incurred damage, equipment involved, extent of damage and estimated cost of material and labor required to complete repairs. It should then be sent to the operating foreman who fills in the second section showing the cause of damage, operator involved, responsibility and corrective action recommended. The report should then be forwarded to the operating superintendent for disposition. It should then be given to the maintenance superintendent, who should make a periodic summary, at least annually, of the total cost of all damage reports received.

A program of this type aimed at reducing the number of repair jobs, if carried out to the full extent, will greatly reduce both operating and maintenance costs, promote safety, and contribute to the efficiency and orderly operation of the departments. But it will be of measurable and permanent value only if its principles and operation are thoroughly understood and accepted by all supervisors involved. Likewise it is essential that corrective action, undertaken in each case, be followed up and enforced without relaxation. The proper operation and care of all equipment and facilities must be a strict job requirement for both employees and supervision. The responsibility for the success of the plan rests with operating superintendents; therefore, it is essential that they be thoroughly sold on the plan.

In the next few years, we may expect the keenest competition in our history. The future prosperity and progress of the steel industry will be contingent upon its ability to keep production costs down to a minimum.

DISCUSSION

PRESENTED BY

L. A. WYND, Electrical Superintendent, Republic Steel Corp., Chicago, Ill.

L. A. TERRY, Superintendent Power and Electric Department, National Tube Co., Tubular Alloy Steel Division, Gary, Ind.

LUKE TUNNY, Superintendent, Steel Producing Maintenance Department, Carnegie-Illinois Steel Corp., South Works, Chicago, Ill.

H. W. NEBLETT, Special Engineer, Inland Steel Co., East Chicago, Ind.

P. E. THOMAS, Project Engineer, Carnegie-Illinois Steel Corp., Gary Works, Gary, Ind.

C. E. GENOVESE, Assistant Division Superintendent, Maintenance, Carnegie-Illinois Steel Corp., South Works, Chicago, Ill.

K. A. DAUGHERTY, Electrical Engineer, National Tube Co., Gary Division, Gary, Ind.

N. S. WALKER, Maintenance Foreman, Tin Mill Cold Reduction Department, Carnegie-Illinois Steel Corp., Gary, Ind.

L. R. KERNS, Kerns Industrial Corp., Chicago, Ill.

C. E. HOMER, Electrical Superintendent, Youngstown Sheet and Tube Co., East Chicago, Ind.

L. A. Wynd: Abuse of equipment is a very touchy subject and causes a great deal of trouble between operating and service departments. One method that seems to be effective in reducing abuses of machinery is to report these occurrences to the district manager, on a damage report.

I think this idea originated in our mechanical department. I thought it so good that I started to use it in the electrical department. The operating superintendents do not like these reports, but nevertheless they pay attention to them and much abuse has been corrected. Abuse of equipment continues to be the worst headache the service departments have and I am glad to see it brought out in the open at this meeting. The only way to make progress is to continue to drive home the fact that no company can continue to abuse equipment the way most have been doing the last few years and expect to produce efficiently.

L. A. Terry: I was very interested in the use of Damaged Equipment Reports. They have been used in our plant and have done a lot of good in inducing operators to be more careful of mill equipment. He mentioned that the maintenance department issued the report and the operating department answered it. But I did not get the third step. What do you do in the third step?

Luke Tunny: In the third step, the report is sent to the operating superintendent by the operating foreman. At this time, the report shows a complete picture of the cause of damage, amount of damage, responsibility, and the corrective action recommended by the operating foreman, so that the superintendent can decide on final disposition. The report is then sent to the maintenance superintendent for filing.

L. A. Terry: Then the second step is to send it to the operating foreman?

Luke Tunny: Yes, and the operating foreman makes out the second section of the report.

H. W. Neblett: What Mr. Tunny has outlined, as to preventive measures, is very good. There must be a card or record system installed, in order to tabulate this report. I am wondering if he does carry a card system that is really a record of the different pieces of equipment; when they were installed, how long they have been in service and the frequency of their maintenance? I am very much interested in that, because there must be some connection between the time when the equipment was put in and when it fails.

Luke Tunny: We do have an equipment record card system at South Works, showing the frequency of changes of cables, shaft assemblies, motors, armatures, etc. In addition to the date, location, and when parts were installed, the card also indicates the reason for the changes. By this method, equipment which requires excessive maintenance is immediately recognized and investigated.

P. E. Thomas: Is it always possible to get a piece of equipment out of service at the time it should come out of service to give it the proper attention from the standpoint of preventative maintenance?

Luke Tunny: Yes, because of the mutual cooperation between the operators and the maintenance department in our division. The urgency for preventative maintenance dictates when the equipment must go down for repairs, and a satisfactory schedule is usually agreed upon.

C. E. Genovese: Something should be said in favor of the department superintendents, for they do not condone abuse.

Some abuse is the direct result of production demand and can be eliminated by design change only. However, there are operating abuses which occur constantly and shift foreman or area foreman condone and cover them up because of the mistaken idea that if the incident is divulged it will reflect on their ability as supervisors. I agree with Mr. Tunny's suggestion of a report which will bring to the attention of the operating superintendent indications of abuse to equipment and with this information steps could be taken to correct the action of the guilty party involved. The superintendent would also be aware of which shift foreman permits the roller to roll cold steel causing damage to tables or which craneman damages crane cables with side pulls as well as numerous other cases of misuse of equipment.

K. A. Daugherty: We believe the damage reports have done a considerable amount of good in our plant at Gary. The superintendent has two main interests at heart beside safety, and those are cost and production. The foreman, in many cases, is interested chiefly in production and does not know or care to know too much about costs. Superintendents should interest and educate their foremen along cost lines if they want successful and profitable departments.

N. S. Walker: What should we term as abuse and what should we term as normal usage of electrical equipment in steel mills? Manufacturers know that their equipment will be given severe usage in a steel mill and they have made remarkable progress in overcoming some of the weak points in their equipment, however, we are still experiencing some trouble with this equipment due to the severe usage that it must withstand. Manufacturers know that this severe usage of electrical equipment is normal usage for a steel mill and not necessarily abuse. I would say that normally what is termed as abuse of electrical equipment in other industries would be classed as normal or below normal usage in a steel mill.

L. R. Kerns: Does this problem not boil down to a question of whether you have to get steel out within a specified time at a higher cost to serve a customer, even though you have to abuse the equipment? Maintenance might be neglected but it might be better to neglect maintenance temporarily rather than shut down the mill and thereby cut off steel from a customer's plant.

Does not the operating man have to be guided by the requirements of management, those men who are sitting up with a profit and loss statement and with the customer picture in front of them making the decisions as to whether they are going to abuse their equipment a little bit by missing a maintenance job that should be done in order to keep their customers' supplied.

Perhaps the maintenance and operating men do not have the complete picture at times, by this I mean perhaps management is pushing the operating men to get out steel and thereby not allowing the mill to be shut down long enough for maintenance purposes. It is very possible that it might be profitable to stand a higher maintenance cost temporarily than it would be to shut down the plant of one of their big customers.

In other words, which is the most important at the immediate moment, production or lower maintenance costs?

P. E. Thomas: I believe there are certain pieces of equipment that cannot be taken out of service at the time it should come out of service for preventative maintenance work, due to the fact that top management feels it is more essential to get out production. In such cases planned maintenance is forestalled and rescheduled.

C. E. Homer: The subject of abuse to equipment in a steel mill should, in my opinion, be divided into two parts.

First is the willful abuse of the equipment and abuse of the equipment through ignorance of capacity and proper use of the equipment. The correction of this first type of abuse I believe can be brought about through education and cooperation between the maintenance departments and the operating departments and the use of some discipline where instructions are willfully disregarded. This education is an internal job and must be talked up and practiced continually by both the maintenance departments and the operating departments. If possible, where equipment is broken down due to lack of knowledge of its capacity, the men involved should be made to understand what caused the breakdown and how it could have been avoided.

The second kind of abuse of equipment may be defined as deliberate overloading or overspeeding to increase mill tonnage or to perform some particular operation. We all recognize that this type of abuse to equipment is a major item and is done frequently in the steel plants. The only way to eliminate this type of abuse is for the maintenance and operating departments to get together and decide whether the inevitable breakdown that will result due to the overspeeding and overloading of equipment, is worth the extra tonnage that may be had as a result of it. I think the main thing to realize in the whole matter of this abuse to equipment is that the maintenance and operating departments should work as a team and realize that they are both striving for the same objective, that is, to get tonnage through the mill and to meet this objective they must cooperate 100 per cent and there is no question that, with this cooperation, and recognizing the other fellow's viewpoint, delays caused by abuse of equipment will be reduced materially.

CONTROLLED ATMOSPHERES FOR ANNEALING GAS

. . . . controlled atmospheres for annealing are being used more and more extensively . . . . proper selection of gas and equipment can greatly improve product finish . . . .

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▲ ANNEALING of steel in one form or another is a process required in practically every industry concerned with the processing of metals. The total tonnage of metals in general which are annealed is probably much greater than that subjected to any other heat-treating process. Thus annealing heat-treatments present a very large and wide field for the application of separately prepared controlled atmospheres. These apply to steel in both finished and semi-finished forms and to a wide variety of types of steels.

The rapid growth and broadening use of controlled atmospheres for all types of annealing processes and particularly to the annealing of steel has come about because the processes usually allow large savings as compared to older methods. In many cases, pickling and other types of cleaning processes are eliminated when metals are "bright annealed." In other cases, control of quality and elimination of decarburization have resulted in large savings. Atmosphere producing equipments and controlled atmosphere furnaces have been developed and improved to the point where they in reality are precision machines as compared to the older types of equipment in vogue before the advent of separately prepared and controlled atmospheres.

This paper will discuss the various types of atmospheres which are being commercially applied to the annealing of a wide variety of steels. Each type will be outlined with particular reference to chemical composition, description of equipment used to produce it, cost of production, and principal points will be discussed dealing with particular phases of chemical effects, importance of water vapor and its control, control of composition, specific applications to certain types of furnaces, atmosphere flow and distribution and consumption as well as practical views on operation and maintenance. Particular emphasis will be placed on the high nitrogen bearing atmospheres and possibility of using them in practically all the important fields of application in the annealing of steel.

The principal atmospheres which will be discussed are as follows:

1. Completely burned fuel gas.
1a. Completely burned fuel gas with CO_2 and H_2O removed.
2. Partially burned fuel gas.
2a. Partially burned fuel gas with CO_2 and H_2O removed.
3. Dissociated ammonia.
4. Partially burned dissociated ammonia.
4a. Completely burned dissociated ammonia.

Any discussion of completely reacted cracked fuel-air gas mixture producing gases high in carbon monoxide, of hydrogen and also of charcoal generators producing gases high in carbon monoxide has been omitted, since these classes of atmospheres would apply only to a very limited number of annealing applications and in general are not very suitable for annealing processes where long cycles of heating and cooling are required.

Also these classes of gas atmospheres are quite active from a chemical standpoint and there is a lot more possibility of inter-action between components of the gases themselves as well as on the metal being heat treated. Since the usual annealing cycle progresses over a wide range of temperatures when heating up, soaking, and cooling, it is not very desirable to use gases which will tend to establish a marked difference in equilibrium conditions as temperatures change rather slowly over a wide range of values.

As an example, gases containing high CO and a very low water vapor and CO_2 content will tend to react to deposit carbon on metallic surfaces during slow cooling. The hot metal surfaces act as a catalyst to promote the reaction of $2CO = CO_2 + C$ particularly in the range of temperatures from 1000 to 1200 F. Since a great many annealing applications allow the relatively slow cooling of large masses of hot metal down through a temperature range of 1200 to 1000 F, it is evident that atmospheres should be used which will not deposit carbon due to inter-action between components of the gas atmosphere. For this reason, the gas atmospheres which are "active" chemically are not desirable for annealing applications.

GENERAL COMBUSTION RANGE

Using methane (CH_4), as an example, the various types of prepared atmospheres which can be made, cover the range from complete combustion to partial cracking to complete cracking. The work "combustion" indicates that sufficient heat energy is evolved

Presented before AISE Annual Spring Conference, Buffalo, N. Y., April 26, 1948

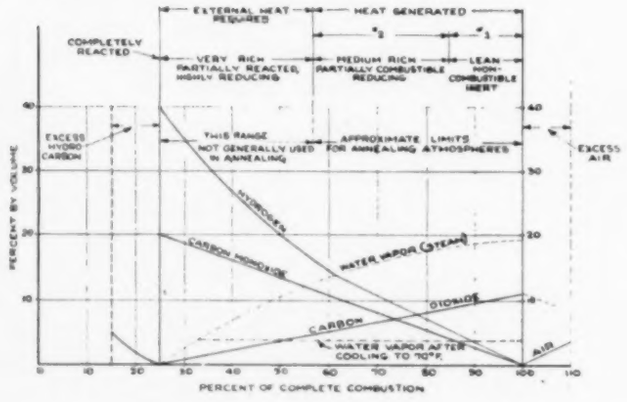
to generate the desired gas without addition of external heat.

The range is illustrated by the set of curves shown in Figure 1. Using methane as the base fuel and mixing it with proper air ratios as indicated on the curve, the variation in approximate gas composition is shown covering the range from complete combustion to partial burning to complete cracking. At a particular air to gas ratio the approximate amounts of hydrogen, carbon monoxide, carbon dioxide, water vapor and nitrogen are given. A curve of this type is useful in giving a general picture of what gas composition can be expected over the range, complete combustion to complete cracking.

Between the right-hand side of the curve showing complete combustion and the left-hand side showing complete cracking, the actual atmosphere compositions obtained will depart somewhat from "idealized" composition indicated on the curve for the following reasons:

1. In the partial combustion range the actual amounts of hydrogen compared to water vapor formed will depend on the design of the gas generator. The same is true for the amount of carbon dioxide compared to amount of carbon monoxide. The variations are due to size of combustion space, time allowed for reactions, type of catalyst used, temperature level of reaction, etc. All of these factors depend on the individual equipment design.
2. In practical gas analysis the amount of water vapor generated in the reactions is always partially removed by condensing out the steam of combustion down to temperatures and dewpoints corresponding to normal atmospheric conditions. Percentage of water vapor given on the curve is that generated during reaction before any condensation or removal.
3. At the lower air to gas ratios on the partial combustion range there are small amounts of residual methane. This will show up on actual gas analyses but is not shown on the general curves being discussed here using methane as an example for the available fuel gas.
4. The approximate ratios are shown at which sufficient net heat energy is generated to make unnecessary the use of external heat. At the very rich ratios external heat is required.

Figure 1 — The properties and composition of fuel gas when combined with various amounts of air are given by the curves in this chart.



In the annealing of steel, we will be concerned principally with those atmospheres dealing with complete or partial burning where sufficient heat energy is derived to use unheated types of gas generating equipment. We will not be concerned with cracked gas atmospheres as shown on left hand side of curve Figure 1 where external heat is necessary.

The cost figures given further on are based on the following assumptions: Raw natural gas at 50c per 1000 cu. ft; electricity at 1c per kwhr; water at 5c per 1000 gal. Use of manufactured gas usually doubles the cost figures for natural gas. Ammonia gas costs are based on 3½c per lb for tank car lots and 16c per lb for cylinder quantities.

COMPLETELY BURNED FUEL GAS ATMOSPHERES

Atmosphere No 1: *Without removal of* CO_2 *and* H_2O.—If any commercially available fuel gas is mixed with the proper amount of air it may be burned under controlled conditions to form CO_2, H_2O and N_2. If this combustion process is carried out with a slight deficiency of air, there is no oxygen present in the resultant atmosphere and small amounts of hydrogen and CO will be present in addition to the gases given above. The resultant atmosphere corresponds to a ratio (assuming methane as the fuel) slightly to the left of the line representing complete combustion shown on curves of Figure 1.

$$CH_4 + 2O_2 + 7.52\ N_2 = CO_2 + 2H_2O + 7.52\ N_2$$

Similar reactions take place with gaseous fuels containing CO, H_2 and illuminants or heavier hydrocarbon gases such as propane (C_3H_8) and butane (C_4H_{10}).

A representative composition of prepared gas when burning methane with a slight deficiency of air would be CO_2=10 per cent, CO=0.5 per cent, H_2=0.5 per cent, CH_4=0.0 per cent, O_2= 0.0 per cent, N_2= 89 per cent. Dewpoint corresponding to approximately room temperature conditions unless auxiliary drying equipment is used. This atmosphere is inert and nonexplosive, and can be set with somewhat higher reducing properties as indicated by range given on the curve of Figure 1. This is desirable in many cases in order to overcome effects of impurities in the furnace on the work being processed.

This atmosphere can be produced for approximately 8c per 1000 cu ft based on assumptions mentioned above. This particular atmosphere is among the cheapest produced since the minimum of fuel is used due to the lean mixtures involved. The atmosphere is not suitable for the bright annealing of steel at elevated temperatures due to the oxidizing action of the CO_2 and H_2O. However, it is classified and mentioned since it is a "base" gas for annealing applications when CO_2 and H_2O are removed.

A typical atmosphere generator for producing this gas is shown in Figure 2 and a schematic general arrangement and flow diagram in Figure 3. The gas mixing pump draws air through a filter; the air flow auto-

matically regulates flow of gas to give a predetermined air to gas ratio for variable flow demand. The air and gas, after flowing through visual flowmeters, mix together at a point preceding the pump inlet. The pump moves the air and gas mixture through the piping system, to the fire-check and burner. The temperature of the combustion tube is sufficiently high to ignite the mixture whose combustion is carried quickly to completion in a catalyst filled refractory bed.

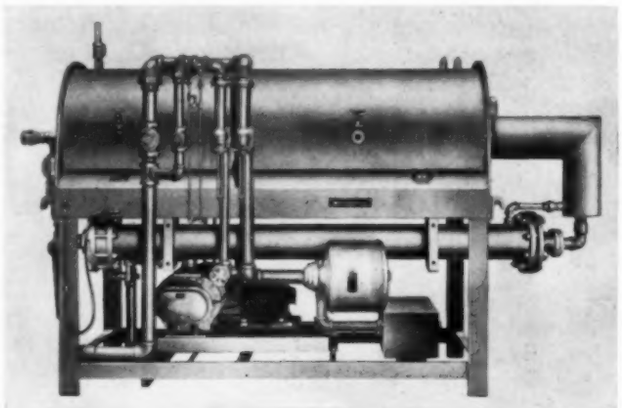
This arrangement also insures thorough reaction so that all traces of oxygen are removed. No outside heat is supplied to the combustion tube since its temperature is maintained by the net heat of combustion. The moisture from the products of combustion leaving the exit side of the combustion tube is condensed out of the gas in a surface condenser and separated from the gas in a water separator and a trap. The gas then may be either used in a furnace or further purified before using by drying, scrubbing out CO_2 or removing small amounts of sulphur.

The gas leaving the water separator is usually saturated with water vapor at a temperature about 10 to 15 F higher than the cooling water used in the surface condenser.

Atmosphere No. 1a: Completely burned fuel gas with CO_2 and H_2O removed. The reaction required to produce this gas is exactly the same as that outlined for the preceding gas. Fuel gas is burned to almost complete combustion on the reducing side. In this instance, however, the carbon dioxide and the water vapor are completely removed by means of separate auxiliary apparatus used in conjunction with the atmosphere generator described.

Using methane for the base fuel, a typical composition of this gas would be as follows: $CO_2 = 0$ per cent, $CO = ½$ per cent, $H_2 = ½$ per cent, $O_2 = 0$ per cent, $CH_4 = 0$ per cent, $N_2 = 99$ per cent. Dewpoint is −40 F. This gas is inert because of its extremely high nitrogen content. A variation of this composition which is usually somewhat more applicable to commercial furnace conditions consist of $CO_2 = 0$ per cent, $CO = 3$ per cent, $H_2 = 3$ per cent, $O_2 = 0$ per cent, $CH_4 =$ trace, $N_2 = 94$ per cent. The gas is still inert but has enough active constituents to overcome oxidizing impurities which enter into the usual furnace application.

Figure 2 — The generator shown can produce either completely burned or partially burned fuel gas.



This gas is produced at a cost of approximately 12c to 15c per 1000 cu ft.

Equipment required to produce this atmosphere consists of an atmosphere generator, the same as that shown in Figure 2. The gas passes from this unit to the carbon dioxide removal system which is described in further detail below. From the carbon dioxide removal system the gas is further dried by means of a combination of refrigerant drying equipment and activated alumina drying equipment described separately. In the cabon dioxide removal system schematically shown in Figure 4, the gas from the generator passes through the absorption tower through special packing material and gives up its carbon dioxide to the liquid which enters at the top of the tower and which trickles down through the packing material. The gas, free of carbon dioxide, collects at the top of the tower and flows through moisture removal equipment and into the further drying equipment mentioned above.

The remainder of the system consists of a recirculating liquid system which is used to absorb the carbon dioxide and which is later heated up to a point where the carbon dioxide may be driven off the liquid which is saturated with carbon dioxide collects at the bottom of the absorption column and is pumped through a heat exchanger to the top of the stripper column. The liquid trickles down through packing material through which is passing heated steam rising from a boiler located at the base of the stripper column. During this passage the carbon dioxide is driven off and is passed through the top of the tower into a condenser which returns most of the heated steam back to the boiler. The carbon dioxide gas is discharged to the atmosphere. The absorbing liquid which has collected in the bottom of the column is pumped back again to the top of the absorption tower through the heat exchanger and cooler.

PARTIALLY BURNED FUEL GAS ATMOSPHERES

Atmosphere No. 2: Partially burned fuel gas without Removal of CO_2 and H_2O. This atmosphere is similar to atmosphere No. 1 except that air-to-gas ratio is smaller and hence products of combustion contain appreciable CO and H_2. Sufficient heat is generated to keep these reducing gases forming without adding external heat, but heat generated is considerably less than for No. 1 (see curve in Figure 1). For this reason, the gas generating equipment is not self starting but must first be thoroughly heated up by operating the unit at a lean air to gas ratio. After the unit is heated the mixture may be made rich enough to produce the rich gas since there is sufficient heat generated to maintain temperature although it will not heat up the equipment from a cold start. With methane as the fuel the following is a typical reaction at 6 to 1 air to gas ratio: $CH_4 + 1.2\ O_2 + 4.5\ N_2 = 1/3\ CO_2 + 2/3\ CO + H_2 + H_2O + 4.5\ N_2$.

For a given air to gas ratio, the amount of H_2 compared to H_2O and the amount of CO compared to CO_2 will vary with the design of equipment used. Efficient catalysts will give higher H_2 and CO and therefore higher reducing properties.

Using a fuel containing practically all methane a typical composition of this atmosphere would be as follows at a ratio of 6 parts of air to one part of gas: CO_2 =5 per cent, CO=10 per cent, H_2=15 per cent, CH_4=1 per cent, N_2=69 per cent, O_2=0 per cent. Dewpoint of the gas corresponds approximately to saturation at room temperature conditions unless auxiliary drying equipment is used. In many applications of this atmosphere, it is desirable to dry the gas to dewpoints of approximately 40 F by using refrigerant dryer equipment.

In general, this atmosphere is combustible and therefore air should be thoroughly purged out from any enclosures in which it might be used. Due to its relatively high nitrogen content and correspondingly low Btu content, it is not as highly combustible as raw fuel gases, but precautions against creation of explosive mixtures with air should always be taken when handling this gas. Also, any leakage of this gas from furnace openings, etc., should be carried away in efficient ventilation systems because the CO content makes it very toxic In a great many applications the gas is burned as it issues from the furnace openings so that harmful CO is converted to comparatively harmless CO_2.

Cost of producing this atmosphere differs from that of No. 1 in that more raw fuel gas is used. Average costs based on assumptions mentioned in first part of article are from 10c to 12c per 1000 cu ft.

The gas generating equipment (equipment A) and comments on operation given for atmosphere No. 1 also apply exactly to No. 2. See Figure 2 for equipment and Figure 3 for schematic arrangement.

Atmosphere No. 2a: Partially burned fuel gas with CO_2 and H_2O removed. This atmosphere is the same as No. 2, except with CO_2 and H_2O removed. This gas is produced using the same equipment and the same reaction described for atmosphere 1a. The only difference consists in operating the primary gas generator at a ratio of air to gas which is richer so as to be able to produce the higher reducing properties in the gas.

A complete gas train for producing either atmospheres 1a or 2a is shown in Figure 5.

DISSOCIATED AMMONIA ATMOSPHERES

Atmosphere No. 3: Dissociated ammonia completely cracked and not burnt. This gas is produced by the cracking of anhydrous ammonia. This gives a gas very high in hydrogen and with very low dewpoint. When the ammonia is thoroughly cracked the composition consists of 75 per cent H_2 and 25 per cent N_2 and the dewpoint is below—40 F.

This gas is produced at a cost of approximately $3.72 per 1000 cu ft using ammonia in the standard small-size containers. This cost can be cut to approximately 93c per 1000 cu ft by using tank car quantities of ammonia. Approximately 22.2 lb of ammonia are required to produce 1000 cu ft of the dissociated gas.

The equipment for producing this gas is shown in Figure 6. It consists principally of an electrically heated catalyst-filled retort chamber through which passes the vaporized anhydrous ammonia.

Atmosphere No. 4: Partially burned dissociated ammonia. This gas is produced by mixing a limited amount of air with dissociated ammonia to produce a pure mixture of hydrogen and nitrogen using a lower hydrogen content than that obtainable with dissociated ammonia. Any proportion of hydrogen compared to nitrogen can be obtained depending on the amount of air mixed with the dissociated ammonia before burning.

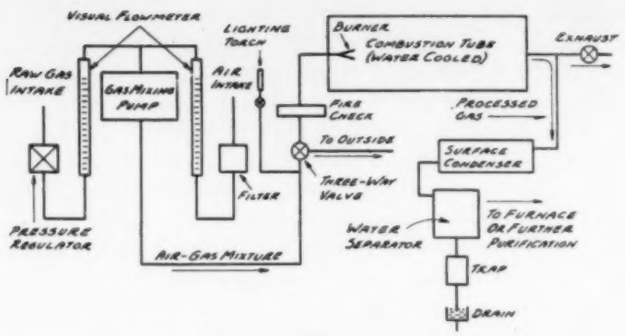


Figure 3 — The schematic arrangement and flow diagram for the gas generator of Figure 2 is shown here.

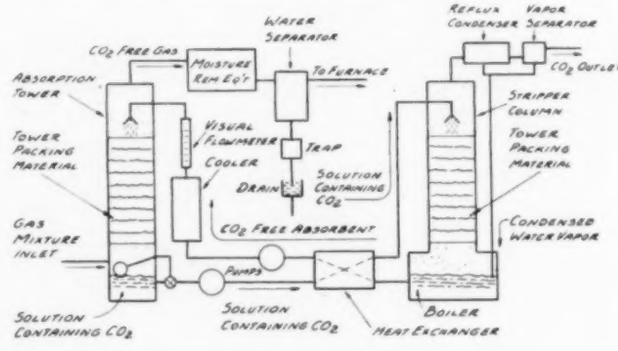
A typical composition of this gas is as follows: H_2 =20 per cent, O_2=0 per cent, N_2=80 per cent. Dewpoint corresponds to room temperature conditions unless auxiliary drying equipment similar to that described under atmosphere No. 2 is used.

A gas containing 20 per cent hydrogen could be produced for approximately $2.55 a thousand, based on small tank quantities of ammonia. This cost would be approximately 65c per thousand if tank car ammonia were used.

The equipment for producing this gas consists of two principal parts, the ammonia dissociator such as that described for atmosphere No. 3 and an additional retort chamber used to burn the mixture of air and dissociated ammonia. An advantage of this equipment is that any proportion of hydrogen compared to nitrogen can be produced up to the limits of dissociated ammonia itself. The equipment is also capable of operating at low turndown values so that no gas is wasted in the process. This is desirable particularly since this gas is much more expensive than the average fuel gas.

Atmosphere No. 4a: Completely burned dissociated ammonia. This gas is produced by the complete combustion of a mixture of air and dissociated ammonia.

Figure 4 — A schematic arrangement for a carbon dioxide removal system is given by this drawing.



A slight deficiency of air is used so that no oxygen results from the combustion process. This gas consists of a very pure mixture of 99 per cent N_2 and 1 per cent H_2, Oxygen is zero. Dewpoint corresponds to room temperature conditions and further drying must be used if the application requires it.

This gas may be produced at approximately $2.30 per 1000 cu ft based on small quantities of ammonia or approximately one-fourth of this, based on using ammonia from tank cars.

The equipment for producing this atmosphere is similar to that described for atmosphere No. 4 except that in some instances it is possible to use an unheated combustion chamber to burn the dissociated ammonia, similar to equipment shown in Figure 2.

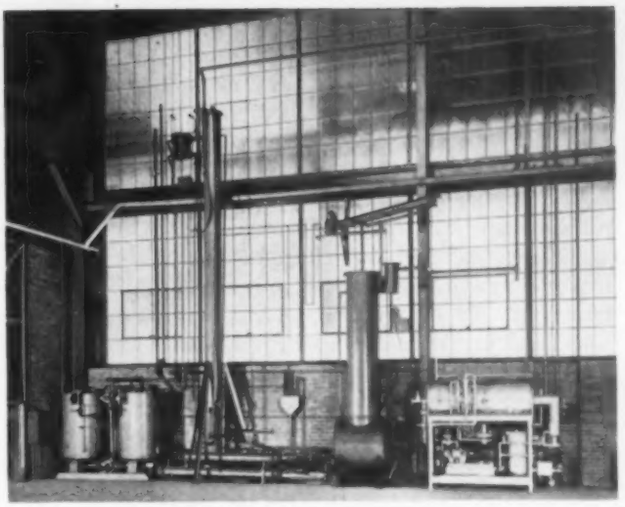


Figure 5 — Mounted along the wall is a complete gas train for producing high nitrogen bearing atmospheres.

DRYING OF GAS ATMOSPHERES

In classifying and describing the various annealing atmospheres, mention was made in each case of moisture content of the controlled atmosphere.

From an equipment standpoint, the various degrees of moisture removal are accomplished by:

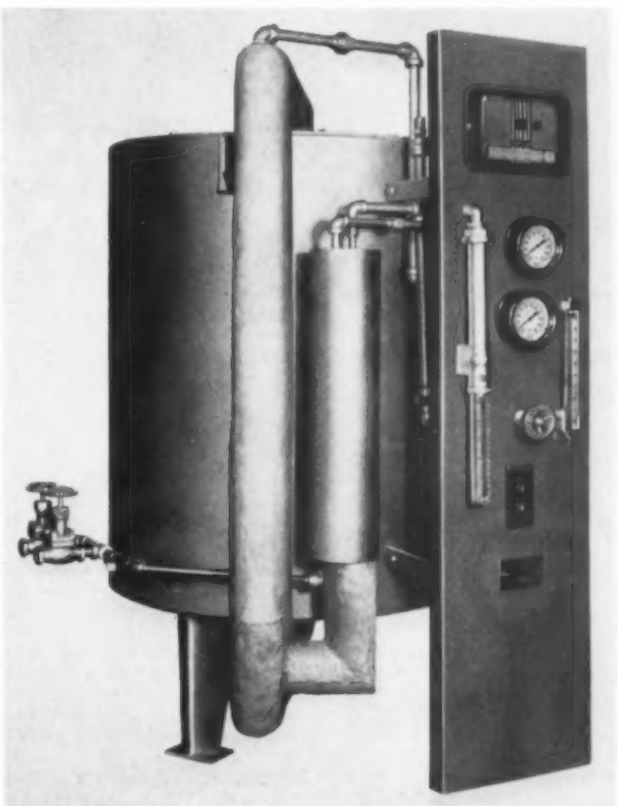
1. *Water Cooling.* Indirect or direct cooling of the gas by means of water. The average generated annealing atmosphere contains water vapor at dewpoint values considerably over room temperature or cooling water temperature conditions. (See curve Figure 1 showing water vapor contents). Thus in all cases a large proportion of the total moisture generated is condensed out and separated from the controlled atmosphere by means of water cooling. The dewpoints thus obtained are usually 10 to 15 F above the temperature of the cooling water.

The curve shown on Figure 7 indicates that the moisture content of the gas is reduced to about 3 per cent by volume (75 F dewpoint) assuming 60 to 65 F water available. In many localities the temperature of cooling water in summer months may go to 80—85 F. In this instance if controlled atmosphere were cooled to 100 F its moisture content would be about 6 per cent by volume. From this it is evident that the dewpoint of the controlled atmosphere gradually varies from season to season as cooling water temperature varies and the level of moisture removal attained depends on actual temperature of cooling water. Thus even though the ratio of air to fuel gas is constant and the fuel gas analysis is constant, the actual gas atmosphere composition from the generator varies when taking into account the dewpoint. In many cases when analyzing controlled atmospheres the variation in dewpoint possible is overlooked and yet this may be the most important factor in possible cause of discoloration or decarburization of the steel.

2. *Drying by refrigeration cooling.* If the controlled atmosphere is cooled to a temperature of about 40 F it will be noted from curve Figure 7 that moisture content of gas is reduced to 0.8 per cent by volume.

This is done by means of refrigerant dryer equipment shown in Figure 8. This atmosphere gas is passed over the outside of a series of finned cooling tubes, the inside of which carried the refrigerating medium circulated by means of a compressor and condensing unit mounted on the side of the gas tight cooling cabinet. It is not practical to attempt to cool the gas much under 40 F, since at lower temperatures the water which is being condensed out of the gas will collect and freeze on the cooling fins. In order to prevent refrigerating to too low a value a temperature control is incorporated with the refrigeration unit so that gas cannot be cooled under 40 F. A typical refrigerant dryer equipment is shown in Figure 8.

Figure 6 — The ammonia dissociator consists principally of a heated catalyst-filled retort chamber through which the vaporized and hydrous ammonia passes.



3. *Drying by use of activated alumina.* In several annealing applications it is necessary to have dewpoints as low as —40 F or less. This is done by passing the gas atmosphere through activated alumina. Equipment illustrated in Figure 9 consists of a dual tower arrangement so that one tower can be used for thorough moisture removal from gas atmosphere while the other is being conditioned for further use. Conditioning consists of heating up alumina bed with circulated heated air until moisture taken up by alumina has been driven off. This procedure is followed by a thorough cooling of the alumina before further use.

Measurement of dewpoint. Recently there has been developed for commercial use continuous recording dewpoint measuring equipment capable of checking dewpoints of very low values. Certain processes may justify the use of the more elaborate and expensive recording equipment. However, in the average application of controlled atmospheres to annealing of steels, simple but accurate means may be used to check the dewpoint of the gas atmosphere since frequent checking is not necessary after atmosphere gas equipment is properly adjusted and operating.

Such a device consists of a glass chamber containing smaller diameter glass tube at the base of which is an integral mounted polished chrome plated well with a high lustre finish. Entrance and exit openings for the gas atmosphere are provided in the outer glass chamber so that the atmosphere whose dewpoint is being measured surrounds the polished chrome well. To measure low dewpoints, acetone or alcohol is introduced inside the small tube and a low temperature stem type thermometer is inserted into the liquid which is a few inches high in the inside tube. Dry ice is introduced into the liquid and this cools the liquid to very low temperatures. As the temperature is lowered a frost will form on the highly polished chrome plated well and the temperature at which this frost forms corresponds to the actual dewpoint of the gas.

SUMMARY OF ATMOSPHERE APPLICATIONS

The discussion to this point has outlined the principal types of controlled atmospheres for annealing with their properties, cost and equipment.

Table 1 gives a summary in tabular form of the annealing atmospheres.

Table 2 gives a summary of the general application fields of controlled atmospheres to the annealing of various types of steel.

The material presented below is a more detailed consideration of these applications and reference to specific experiences and problems of chemical effects furnaces, flows, tests, etc.

LOW CARBON STEEL

The general problem is to "bright" anneal without oxidation. Decarburization of carburization is usually

TABLE I

Composition and Cost of Typical Controlled Atmospheres for Annealing of Steel

Atmosphere	Description	Air to gas ratio	N_2	H_2	CO	CO_2	CH_4	O_2	Dew point	Gas for M cu ft atmosphere	Cost per atmosphere	Nature of atmosphere
No. 1	Completely burned fuel	10:1(a)	89.0	0.5	0.5	10.0	0.0	0.0	(b)	115(c)	0.08(d)	Noncombustible, slightly reducing.
No. 2	Partially cracked fuel (self propelled)	6:1(a)	69.0	15.0	10.0	5.0	1.0	0.0	(b)	145(c)	0.10(d)	Combustible, toxic, medium reducing.
No. 1a	Lean Exogas scrubbed of CO_2 and H_2O	10:1(a)	94.0	3.0	3.0	0.0	0.0	0.0	-40 F	125(c)	0.14 to 0.40(e)	Noncombustible, inert.
No. 2a	Rich Exogas scrubbed of CO_2 and H_2O	6:1(a)	72.0	16.0	11.0	0.0	1.0	0.0	-40 F	150(c)	0.16 0.42(e)	Combustible, toxic, reducing.
No. 3	Dissociated ammonia	No air	25.0	75.0	0.0	0.0	0.0	0.0	-50 F	22.2 lb NH_3	1.00 4.00(f)	Combustible, reducing.
No. 4a	Dissociated ammonia completely burned	1.88:1(g)	99.0	1.0	0.0	0.0	0.0	0.0	(b)	13.35 lb NH_3	0.65 to 2.30(f)	Noncombustible, inert.
No. 4	Dissociated ammonia partially burned	1.25:1(g)	80.0	20.0	0.0	0.0	0.0	0.0	(b)	15.0 lb NH_3	0.85 to 2.55(f)	Combustible, slightly reducing.

(a) Air to gas ratios are representative for natural gas containing practically nothing but methane. For high hydrogen city gas, ratios are about 50 per cent of values given; for city gas with medium hydrogen and high CO, ratios are about 40 per cent of values given. For propane, ratios are approximately twice the values given in the table, and for butane about 3 times.

(b) Dew points correspond to about 10 F above room temperatures unless auxiliary drying equipment is added. Dew point may be reduced to 40 F by refrigeration equipment; to minus 40 F or less by use of absorbent towers.

(c) Values are in cu ft for high methane natural gas. For various types of manufactured city gas, double the values given. For propane, requirements are half of values given, and for butane, one-third.

(d) Costs figured on raw natural gas at 50c per M cu ft, electricity at 1c per kwhr, water at 5c per M gal. Use of city gas usually doubles the cost figures given.

(e) Low value when reactivating moisture absorbent with steam: high value when using electrical heat. Steam at 30c per 1000 lb.

(f) Costs based on 3.5c per lb of NH_3 in tank car lots and 16c per lb for cylinder quantities. Electricity for dissociation at 1c per kwhr.

(g) Dissociated ammonia.

TABLE II

Atmospheres Suitable for Heat Treatment of Different Steels

Material processed	Process	Temperature range, F	Time cycle ("Long" if over 2 hr)	Required surface	Atmospheres which will give desired results	Atmospheres commonly used
BRIGHT OR CLEAN ANNEALING						
Low carbon steels	Anneal	1200 to 1350	Long	Bright	1a, 2, 2a, 3, 4, 4a	2
Medium carbon steels	Anneal (No decarburization)	1200 to 1450	Long	Bright	1a, 2a, 3, 4, 4a	1a
High carbon steels	Anneal (No decarburization)	1200 to 1450	Long	Bright	1a, 2a, 3, 4, 4a	1a
Alloy steels, medium and high carbon	Anneal (No decarburization)	1300 to 1600	Long	Bright or clean	1a, 2a, 3, 4, 4a	1a, 2a
High speed tool steels including molybdenum high speeds	Anneal (No decarburization)	1400 to 1600	Long	Bright or clean	1a, 2a, 3, 4, 4a	1a
Stainless steels, chromium and nickel-chromium	Anneal	1800 to 2100	Short and long	Bright	3	3
High silicon steel, electrical sheet	Anneal	1900 to 2100	Long	Clean	1a, 4	1a, 4

not a problem on low carbon steels. Reducing atmospheres in the range designated as No. 2 will bright anneal low carbon steel. If the steel contains scale or oxide before annealing, the atmosphere will also reduce the scale.

Although thorough removal of CO_2 and water vapor is not required for bright annealing of low carbon steel, there are practical limits to the amount of water vapor which can exist in the furnace particularly during the slow cooling of large batches of steel if discoloration, bluing or heavier oxidation is to be avoided. The permissible amount depends on the reducing power of the atmosphere as related to the volume of hydrogen and carbon monoxide simultaneously present in the controlled atmosphere.

Figure 10 shows an approximate practical relation between the dewpoint of the controlled atmosphere and the minimum values of H_2 and CO which are required to prevent oxidation of steel on slow cooling. These values are based on experience factors associated with slow cooling of large batches of low carbon steel strip.

As an example, for a given dewpoint of the gas atmosphere, if the H_2 content of the gas is less than the value shown on the curve then oxidation or some discoloration may take place on slow cooling.

Also for a given dewpoint, if CO content of gas is greater than value shown on curve, some etching or soot deposition may take place on surface of steel during slow cooling. Conversely for a given value of CO as indicated on the curve, if the dewpoint of the gas is less than value of dewpoint indicated then there is a practical possibility of some etching or soot deposition.

Usually etching or soot deposition is caused by too much CO content of gas compared to dewpoint or to too dry a gas compared to CO values. It should be emphasized that practical limits shown on the curve apply principally to the relatively slow cooling of large batches of steel. In the case of continuous annealing of strip, wire, tubing, etc., wider latitude of dewpoints compared to H_2 and CO are possible without evident oxidation or etching, since the time at the temperature at which these reactions take place is relatively quite small and the steel cools so quickly through this range that visually any action is not evident even though the gas atmosphere is potentially capable of some oxidation.

The temperature at which oxidation takes place is usually in the region of 1100—800 F and the action takes place during the cooling cycle.

EVALUATION OF CAUSE OF DISCOLORATION OF STEEL

Excluding the stainless steel groups, the two elements in the furnace atmosphere which will discolor or oxidize steel are water vapor and very small amounts of molecular oxygen.

Dewpoint in itself can be measured as indicated in previous discussion above. Molecular oxygen cannot be measured quantatively by an ordinary means of analysis such as an orsat apparatus. However, if molecular oxygen is present in the furnace in sufficient quantities to cause discoloration, the effect can be tested by using a simple test device which is easily made up. This test device is shown in Figure 11.

It consists of a piece of ⅛ in. pipe about 18 in. long threaded at each end with a copper tubing connection at one end and a small petcock at discharge to adjust flow to a very small value through the tube. This petcock is removable so that a ⅛ in. diameter steel rod about 17 in. long which is a little shorter than the tube can be inserted into the pipe from the discharge end. The sampling end consisting of the copper tubing with suitable fittings is connected to a point on furnace where an atmosphere sample can be drawn off and the atmosphere flows through the sampling tube. The discharge petcock should be wide open to allow thorough purging of the sampling tube. With a furnace pressure of from ⅛ to ½ inch of water, this purging takes only a few minutes. After purging, the flow is reduced to a small value by partially closing the discharge petcock. This places the complete sampling tube under pressure.

A torch flame is played on the outside of the pipe at a point about halfway along its length and the surface of the pipe at this point is locally heated to bright red or dull yellow color and held at this color for a period of about 3 minutes after the color is attained. This transfers heat to the ⅛ in. diameter steel rod inside at a sufficient temperature to get a small local portion of this rod to at least a red heat. Also there exists along with this all gradations of temperature from red heat down to almost room temperature. Thus the color or oxidizing effect of the atmosphere over the complete range of temperature can be observed after the sample is cooled and the rod is removed from the tube. If molecular oxygen or water vapor or both are present in sufficient quantity to cause discoloration, the sample rod will show gradations of color from a gray at the hottest portion all the way through the various temper colors of purple, blue on down to a straw color.

If the sample rod is bright or only a slight straw color then the atmosphere is capable of producing bright steel. To segregate discoloration due to water vapor from that due to free molecular oxygen, a ⅛ in. diameter bright copper rod can be tested using same procedure as described for the steel rod. If copper rod is bright when the same atmosphere discolors the steel rod then the cause of discoloration is water vapor only, since water vapor will not discolor the copper rod. The cause of steel discoloration would then be due to excess water vapor only.

If copper rod is also discolored then free oxygen is present unless copper has been discolored due to presence of sulphur in the gas atmosphere. Whether the copper has been discolored due to action of sulphur instead of oxygen can be determined by dipping sample rod in dilute sulphuric acid. The oxide will be removed while the sulphur discoloration remains.

This simply made testing device can readily be used to give considerable information on the reasons for discoloration and what element in the atmosphere is causing discoloration.

The atmosphere from the gas generator as well as from the furnace can be tested to insure that atmosphere from generator itself is suitable for producing bright steel.

Testing of this nature can serve as a practical guide to the real reason for source of discoloration. It is a scheme whereby the effect of the atmosphere is directly measured by visible effect on the metal. The sampling tube used should be thoroughly cleaned and be free of any foreign metal before use. One way to clean the inside of the pipe is to pass atmosphere through it while heating each portion of the outside to a red heat and holding there for a few minutes. This allows the reducing atmosphere to clean up any oxide inside the pipe and drive off any oil or other impurities which could affect the color of the sample rod.

HIGH CARBON AND ALLOY CARBON STEELS

Since these steels must be annealed in the critical range or a little above the critical range and held in these ranges for many hours, the controlled atmosphere must be practically "neutral" to prevent any loss of carbon from high carbon steels or any gain of carbon in medium carbon alloy steels.

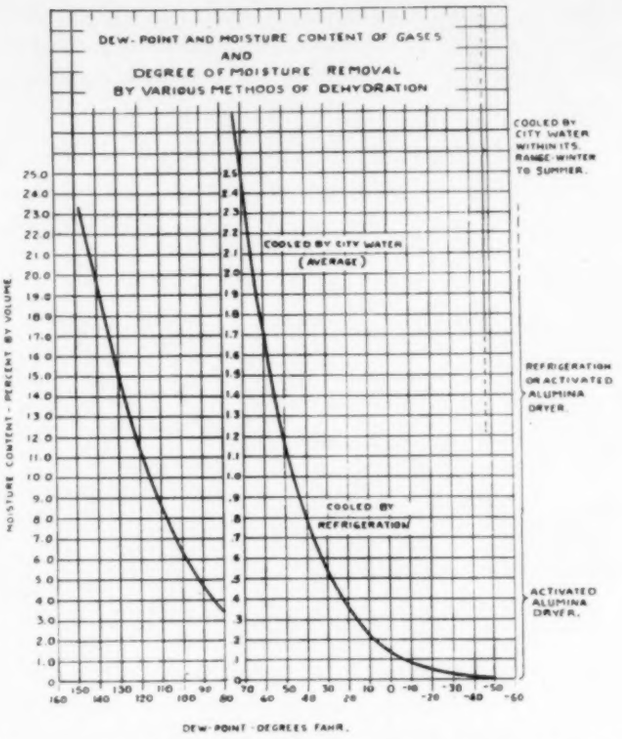

DEW-POINT AND MOISTURE CONTENT OF GASES AND DEGREE OF MOISTURE REMOVAL BY VARIOUS METHODS OF DEHYDRATION
COOLED BY CITY WATER WITHIN ITS RANGE WINTER TO SUMMER.
COOLED BY CITY WATER (AVERAGE)
REFRIGERATION OR ACTIVATED ALUMINA DRYER.
COOLED BY REFRIGERATION
ACTIVATED ALUMINA DRYER.
MOISTURE CONTENT - PERCENT BY VOLUME
DEW-POINT - DEGREES FAHR.

Figure 7 — The curve shows the per cent by volume of the moisture content as a function of the dew point.

Atmosphere No. 1a set for 3 to 4 per cent CO and approximately the same amount of H_2 has been found quite suitable for long cycle annealing of high carbon steels without oxidation or decarburization.

General experience has indicated that this atmosphere will overcome the effects of oxygen impurities which enter into all industrial furnace practice and which must be compensated for by some chemically active constituents in the atmosphere. In other words it is not desirable to have the atmosphere too inert but only relatively inert.

From a practical standpoint, it is recognized that an atmosphere in true equilibrium or absolutely neutral does not actually exist in actual annealing furnaces where large amounts of steel are involved or where heating up and cooling down through a wide temperature range is involved.

An atmosphere is required for high carbon and alloy steel annealing which does not involve chemical changes in the atmosphere and on the work through a wide temperature range. At first glance it would seem that an atmosphere of practically 100 per cent nitrogen would be satisfactory but experience shows that decarburization and oxidation both result when using nitrogen. Experience also shows that high CO alone is not good due to intergas reaction to form a soot and high hydrogen alone is not good due to extreme tendency to decarburize when relatively small amounts of water vapor are present. Moderate amounts of CO and H_2 together give an excellent compromise and experience has indicated that atmosphere No. 1a with CO of 3 to 4 per cent and approximately the same amount of

hydrogen gives an inert gas which is still active enough to overcome oxidation impurities. The gas itself is low enough in CO and H_2 and also water vapor that intergas reactions are very small and gas reactions on metal if they are theoretically possible proceed at such a very slow rate that metallurgical effects are negligible and not measurable.

An example of this can be cited in the bright annealing of 1.25 per cent carbon steel strip. After steel reached an actual steel temperature of 1350, it was held there for 8 to 10 hours before starting to slow cool. The photomicrograph shown in Figure 12 shows the edge of the strip at 500 magnification. In this case, the structure is practically completely spheroidized and insofar as the affect of the atmosphere is concerned, there is no evidence of decarburization or intergranular oxidation. The atmosphere from the furnace contained about 4 per cent CO and 6 per cent H_2 with a dewpoint of about —30 F. This is a good example of the atmosphere being practically "neutral" with respect to this high carbon steel.

TOOL STEEL AND ALLOY CARBON BAR STOCK

This class of steels usually requires higher annealing temperatures than straight carbon strip, rod and wire. Since possible reaction rates of the controlled atmosphere with the steel surface are much faster at these higher temperatures, it is of great importance to use an atmosphere which is chemically stable within itself and also which is about neutral on the steel so that no decarburization or carburization takes place.

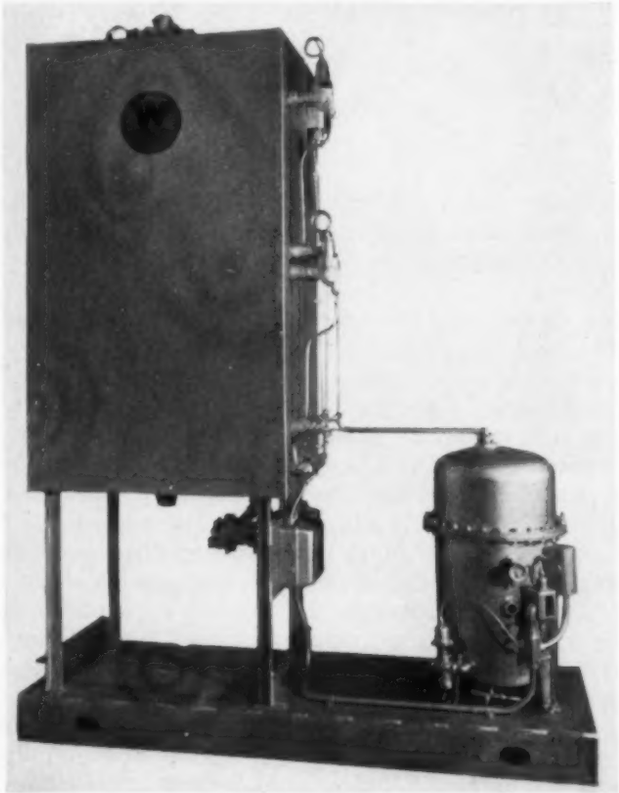
To meet this requirement, experience has shown that atmosphere 1a described above with a setting to give around 4 per cent CO and about 5 to 6 per cent hydrogen will allow annealing without additional decarburization or oxidation.

Hot rolled stock of either coiled rod or straight bar on which mill scale has been pickled off before annealing and which contains a skin of hot mill decarburization anywhere from 0.005 to 0.010 in. deep can be successfully annealed without any additional decarburization using atmosphere 1a. In other words, the effect was to anneal by maintaining a "status quo" which is usually not possible without additional decarburization when annealing in air or products of combustion or when using the "pack" method by surrounding the work with iron chips, etc. Annealing bar stock and tool steel bars, etc., without additional decarburization presumes the proper furnace equipment which is capable of maintaining the required atmosphere. Comments on this are given in another section of the paper.

Atmosphere annealing of alloy or tool steel rod and bar stock without removal of mill scale and without additional decarburization appears possible on a commercial scale.

Pilot investigations indicate that atmosphere No. 1a again is suitable, except that for some applications the CO content should be increased to a little higher value such as 6 to 7 per cent with corresponding increase in H_2. This combination is reducing enough at temperatures well below the critical range for these steels so that the products of reaction of the atmosphere with the mill scale can be formed and purged out before the steel is heated up to its critical range. These products of reaction with the scale are water vapor and CO_2 both of which would be decarburizing to the higher carbon steels at temperatures in and above the critical.

Figure 8 — In the refrigerant dryer, the atmosphere gas is passed over a series of thin cooling tubes.



SILICON STEELS

This class of steel varies widely in silicon content and in annealing temperatures used. Also atmosphere requirements are not necessarily as critical when handling the steel continuously in strip form as compared to batch handling in coils or sheets, due to difference in time cycles.

The lower silicon content steels which can be annealed at lower temperatures, usually require only an atmosphere to prevent oxidation. Atmosphere No. 2 is suitable. At the lower temperatures the possible reaction rates are probably very slow and possibility of carbon pick up and oxidation of silicon from water vapor is too small to seriously affect the magnetic properties desired.

On the higher silicon content electrical steels, the principal problems from an atmosphere standpoint are:

1. Prevention of oxidation.
2. Prevention of carbon pickup.

Reaction of the atmosphere with respect to carbon content of the steel is on the opposite end of the scale as compared to annealing of high carbon and alloy carbon steel. In the case of high carbon steel, the prob-

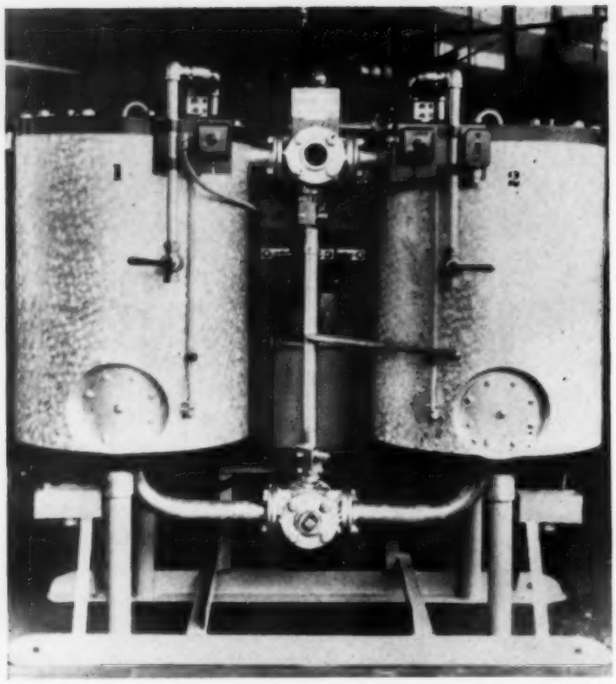
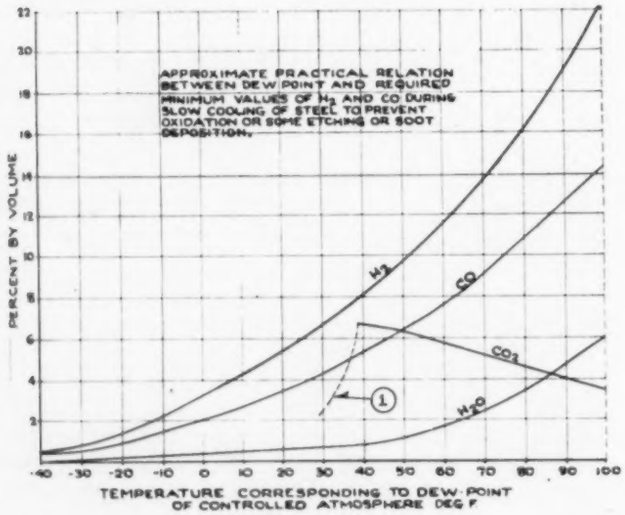


Figure 9 — The activated alumina drier consists of a dual tower arrangement so that one tower can be used for moisture removal while the other tower is being prepared for further use.

lem is to have atmosphere contain sufficient carbon potential to prevent loss of carbon content from the steel. In the case of electrical silicon steels the problem is to prevent any gain in carbon with the carbon values very low to start with, such as 0.05 per cent or less.

Thus atmospheres which are normally considered to be very decarburizing to the higher carbon steels at elevated temperatures will be somewhat carburizing to the very low carbon content silicon steels, particularly at temperatures over 1600 F.

Figure 10 — The curve gives relation between the dew point and required value of hydrogen and carbon monoxide to prevent oxidation of steel. The carbon dioxide present (1) is assumed to be greatly reduced or removed at lower dew point values, since intergas reactions will tend to increase dew point and resultant oxidation tendency on steel as it cools.


APPROXIMATE PRACTICAL RELATION BETWEEN DEW POINT AND REQUIRED MINIMUM VALUES OF H2 AND CO DURING SLOW COOLING OF STEEL TO PREVENT OXIDATION OR SOME ETCHING OR SOOT DEPOSITION.
PERCENT BY VOLUME
H2
CO
CO2
H2O
1
-40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100
TEMPERATURE CORRESPONDING TO DEW-POINT OF CONTROLLED ATMOSPHERE DEG F

Since the high silicon steels are annealed at temperatures from 1800 to 2100 F the possible reaction rates are relatively faster and if the atmosphere has a slight carburizing tendency, then enough carbon pickup may take place to affect the desired magnetic properties.

Thus since atmospheres containing CO or a trace of CH_4 (methane) or both are not suitable and for high temperature, No. 2 would not be suitable. Although the CO bearing atmospheres which may tend to carburize very low carbon silicon steels may be neutralized with water vapor, it is not good to have water vapor present during high temperature silicon steel annealing, due to the tendency for water vapor to oxidize the silicon and also the iron itself. Therefore, the required atmosphere should be very dry and be free of any carbon bearing components such as CO or CH_4 in order to obtain the best electrical properties when annealing high silicon steels at high temperatures.

To meet these requirements, the following commercial atmospheres may be used:

1. Pure dry high hydrogen bearing gases such as dissociated ammonia (atmosphere No. 3).
2. Pure dry hydrogen nitrogen mixtures such as those obtained from burning and then drying dissociated ammonia. Atmosphere 4a set for almost complete combustion is one possibility.
3. Practically pure dry nitrogen such as that obtained from complete burning of fuel gas and subsequent removal of CO_2 and water vapor, (atmosphere 1a set for practically complete combustion with negligible CO content).

Possibilities 2 and 3 are cheaper and more commercial on hot rolled high silicon sheets where the optimum results possible with high hydrogen gases are not readily attained when stacking wide flat sheets, and where it is from a practical standpoint more difficult to remove and control low water vapor content locally inside the pack due to stacking of the sheets.

STAINLESS STEELS

The requirements for a true bright anneal on the high chromium and chrome nickel stainless steels are an atmosphere which contains no oxygen, practically no water vapor, no carbon monoxide, no carbon dioxide and no sulphur. In other words oxygen either in free or combined form cannot be tolerated or discoloration will take place.

Pure dry hydrogen or dissociated ammonia will bright anneal stainless steel but only under operating conditions where all possible traces of oxygen or water vapor impurities can be kept out of the atmosphere surrounding the work.

From a practical standpoint, this presumes a full muffle and muffle must be sealed and constructed in such a way that all impurities are kept out. Experience has shown that if muffles themselves are not extremely tight, that oxygen impurities can "back diffuse" through the crack in the muffle and cause discoloration even with reasonable atmosphere pressure inside the muffle. For this reason, it is desirable to use the hydrogen atmosphere both inside and outside of the muffle and thus obtain a "double" muffle effect.

Due to these limitations in practical operation, commercial bright annealing of stainless has been limited to strand annealing of wire, rod and very narrow strip where the muffle itself consists of relatively small diameter tubing which can be made relatively heavy and tight and be sealed better at the ends.

Where "bright" annealing is not required and a thin film of very stable oxide can be used or where it is desirable to limit oxidation and not pickle off any oxide, the fuel gas atmospheres, particularly atmosphere 1a will do a satisfactory job.

POSSIBILITIES OF EXPLOSION

Gas atmospheres, after combustion, which contain greater than approximately 14 per cent H_2 and CO combined are combustible when mixed with proper amounts of air. Under typical conditions this means that CO content should not be over 6 to 7 per cent and hydrogen over 8 per cent. For total combustibles less than these values, various mixtures of air and gas atmosphere will not burn at room temperatures and respect to time of purge and flow rate of gas used when purging.

VARIATION IN COMPOSITION OF ATMOSPHERE GENERATED

With the conventional pressure responsive type proportional gas governor or mixer, the ratio of fuel gas to air is held reasonably constant and resultant output gas from the atmosphere generator is reasonably constant. This scheme presumes, however, that the fuel gas itself is of reasonably constant quality. If the composition of the fuel gas itself varies, then the atmosphere generated will also vary independent of accurate ratio control.

Fortunately in a great majority of bright annealing applications, absolute constancy of the fuel gas composition is not a prime requirement and some variation is not harmful. However, some processes such as silicon steel annealing and non-decarburizing annealing of high carbon steels require close control of atmosphere

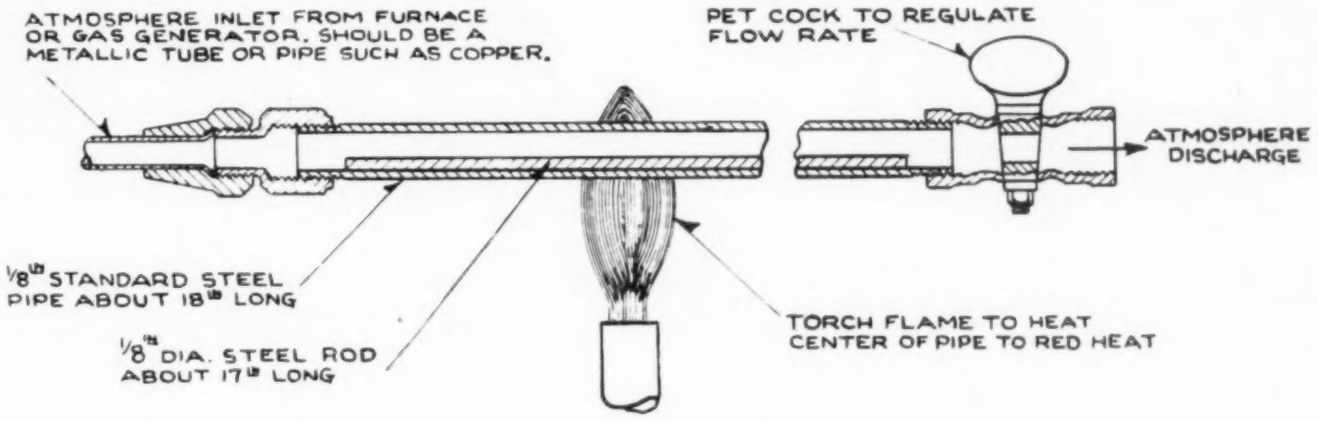

ATMOSPHERE INLET FROM FURNACE OR GAS GENERATOR. SHOULD BE A METALLIC TUBE OR PIPE SUCH AS COPPER.
PET COCK TO REGULATE FLOW RATE
ATMOSPHERE DISCHARGE
1/8" STANDARD STEEL PIPE ABOUT 18" LONG
1/8" DIA. STEEL ROD ABOUT 17" LONG
TORCH FLAME TO HEAT CENTER OF PIPE TO RED HEAT

Figure 11 — The test setup for determining whether a furnace atmosphere is capable of producing bright steel is a simple one.

cial precautions concerning purging of inner covers of annealing furnaces are not necessary.

For larger amounts of combustibles or for atmospheres containing high percentages of H_2, it is necessary to purge inner covers with sufficient atmosphere to insure insufficient air to support combustion when hot furnace is placed over the inner cover. A portable sampling device which measures the specific gravity of the mixture under the cover is quite handy and practical to use to determine whether an inner cover has been sufficiently purged from a safety standpoint. For instance, a typical specific gravity of atmosphere No. 2 containing 10 per cent CO and 15 per cent H_2 and 5 per cent CO_2 is about 0.96. When the gravity meter reading (with air equal to gravity to 1.0) is approximately 0.96 then purging is quite completed.

Gases containing higher hydrogen contents have much lower gravity values so that the spread is much greater and it is relatively easy to check how far purging has progressed. The advantage of this method is that it is independent of judgment of operator with composition. In the present day period of gas shortages and in locations where fuel gas sources may at times consist of a mixture of two or more gases, it is sometimes necessary to insure constant gas atmosphere output composition independent of fuel gas variation or any other variation which might vary the required composition.

For these special cases controlling equipments are now available which can be operated to automatically compensate for changes of input fuel. These instruments sample the output atmosphere from the generator and if this varies beyond the required limits, a valve in the inlet air or gas line automatically adjusts the ratio to obtain the proper output atmosphere. Instruments available to do this measure various properties of the output atmosphere. These are:

1. Thermal conductivity of the atmosphere.
2. Amount of combustibles in the atmosphere.
3. Specific gravity of the atmosphere.

The specific type suitable for the job depends on the type of atmosphere being measured. In general the

thermal conductivity types are more suitable for atmospheres containing considerable hydrogen. The other types are more suitable for atmospheres high in nitrogen and with only a small amount of combustibles.

ATMOSPHERE FURNACE ANNEALING PRACTICES

Separately prepared atmospheres even under ideal commercial conditions are subject to some change in composition after they are introduced into the annealing furnace. These changes are due to impurities on the steel and to oxygen impurities which are an unavoidable part of normal practice. Some changes are also due to interaction of the atmosphere with the steel and between components of the gas itself. In general, however, the goal is to use atmospheres and furnace practices which will keep these changes to a minimum or at least will control the changes to obtain the desired result.

Certain basic practices will be briefly discussed in an attempt to point out possible reasons for variations in results from various plants using the same basic atmospheres. It is understood that there are many variations in furnace type and design which also alter the results using the same basic atmospheres. However, certain common practices apply to a great variety of designs. The common problems briefly discussed here deal with purging, amount of atmosphere used, seals, distribution of atmosphere and pressures.

PURGING

Aside from initial purging required for safety reasons when using combustible type atmospheres which was discussed above, there is a definite amount of purging required to obtain required purity of atmosphere before starting to heat the metal.

In annealers using inner covers, purging of air from under the cover should be done until oxygen content is less than one per cent. This requires between 4 and 5 complete changes of the net volume of the gas space between the inner cover and the charge. This volume can be calculated and this together with rate of atmosphere feed used will determine time required for purging.

As an example, if the net open space between charge and cover is 50 cu ft and desired purging time is one hour, then 250 cu ft per hr of atmosphere would be the flow rate required to allow 4 to 5 volume changes before heating. If longer times were available for purging, lower flow rates could be used.

ATMOSPHERE CONSUMPTION

In annealing using inner cover, a certain minimum flow rate is required to sweep out all vapors, drawing compounds, water vapor formed, etc., during the early part of the heating cycle in order to eliminate the effects of these impurities when the steel approaches its annealing temperatures and to eliminate harmful chemical reactions which usually do not take place until higher temperature levels are reached. Most oil impurities and products from drawing compounds, etc., will vaporize off at temperatures of 700 F and less. Hence, atmosphere flows during the earlier portions of the heating up cycle should be sufficient to purge out these vapors and a clear color to exhaust atmosphere should be obtained before hottest portions of the steel reach approximately 700 F. Experience with the actual charge and furnace used will dictate what the actual value of the flow rate should be to attain this "sweep out." Insufficient flows during this portion of the cycle, which leave this vapor still mixed with atmosphere at the higher temperature, will result in carbon or soap compounds being "baked" into the surfaces of the steel and its color and appearance will not be very acceptable no matter how good the atmosphere itself is.

SAND SEALS AND LIQUID SEALS

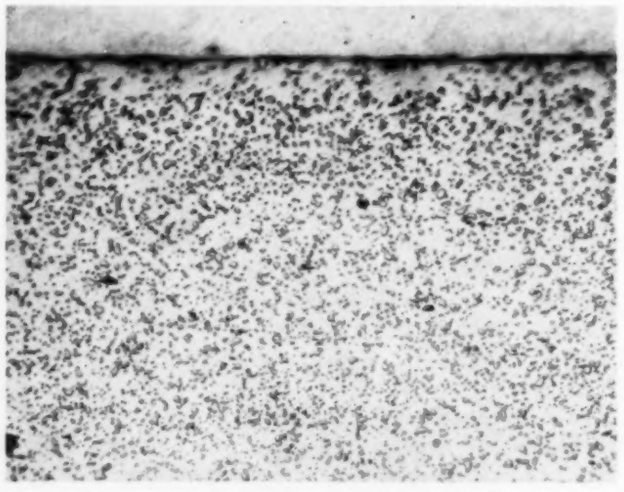
Use of inner covers with sand seals at base of the cover requires a certain minimum flow to give off atmosphere to insure against back diffusion or leakage of atmosphere outside the cover back into the inner cover.

Of greater importance is the pressure actually existing under the annealing cover. To insure against back diffusion through the seal, or actual back flow through the seal due to any small leaks in the cover (particularly the upper portion) the pressure under the cover should be greater than any possible chimney action. The necessary pressure is a function of the height of the inner cover.

An approximate safe rule to follow to insure sufficient operating pressure to prevent inward leakage is 0.1 in. of water column for every foot of height of the inner cover. This usually means at least 0.5 in. of water pressure underneath the inner cover.

It should be noted that proper measurement of the actual pressure inside the inner cover cannot be made by tapping the inlet atmosphere line leading to the cover, since there is always a pressure drop in this line between the tapped point and the inner cover due to

Figure 12 — This photomicrograph of bright annealed 1.25 per cent carbon steel strip is shown at a magnification of 500 times.



flow of the atmosphere. To properly measure the static pressure under the inner cover, a separate pipe should lead to the inner cover and the pressure manometer should be connected to this pipe. This is a static pressure connection only and no flow exists.

When maintaining the required minimum pressure, the amount of atmosphere required will vary with the depth of seal and particle size of sand used. Using a very fine grade of sand and about 5 in. of depth of sand, the average consumption will be about 5 cfhr per lineal foot of sand seal.

However, in estimating overall atmosphere requirements it is better to allow for flow rates of 8 to 10 cfhr per lineal foot of seal. This takes care of the variables associated with size of particles of sand, height of cover, minor cover leakage and imperfect maintenance of sand to proper depth.

In the case of liquid type inner cover seals, the pressure maintained under the cover should also be at least 0.1 in. of water for each foot of cover height in order to insure against undue contamination through leakage paths in the cover should they exist. In this case, however, the flow rate can be cut down to very small values or even be shut off (by closing valve on exhaust side) after vapors etc., have been properly purged out during heating up cycle.

For best control of quality in annealing high carbon steels, liquid seals are to be preferred over sand seals since control of atmosphere purity is easier to maintain. If sand seals are used, the higher flow rates of 8 to 10 cfhr per lineal foot of seal are better from standpoint of consistent control of quality of product when considering high carbon and alloy steel annealing without decarburization.

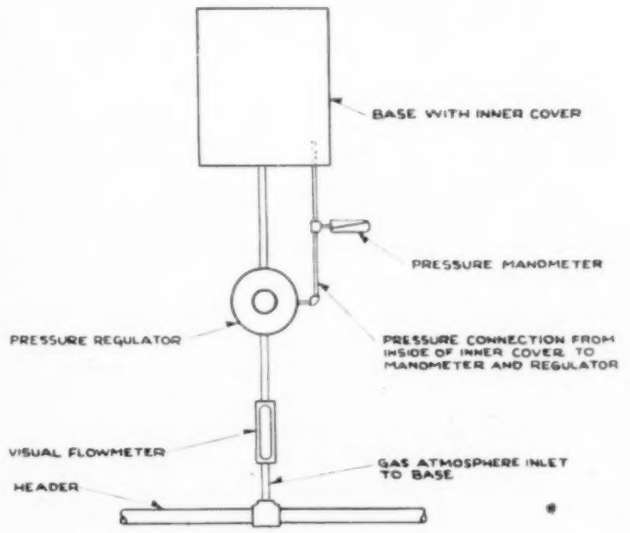
DISTRIBUTION OF ATMOSPHERE AMONG FURNACES

In many instances, troubles are encountered when feeding controlled atmospheres to annealing furnaces due to uneven distribution of the amount of atmosphere to each furnace. These troubles are usually due to insufficient pressures in the header feed pipes or too small a header pipe. Also lack of measurement of conditions of flow and pressure at each inner cover will cause irregular results. The equipment required to do this is simple and cheap compared to cost of furnace equipment and compared to operating losses due to lack of control.

Figure 13 illustrates schematically the elements of equipment which should be an integral part of each base position and to make the flow to each base independent of flow settings to other bases from the same header. This consists of a pressure regulator, visual type flowmeter, and pressure manometer at each base position. It is desirable to connect downstream side of the pressure regulator so that it is responsive to the pressure under the inner cover. Also as mentioned above, the pressure should be measured from under the cover and not in the inlet feed pipe.

Proper distribution presumes proper size of header pipes and sufficient header pressure to get maximum flow rates required. In general, the area of the header pipes should be at least twice that of the total area of feeder pipes to each base. Average pressures in header pipes should be at least 4 to 6 oz per sq in. in order to insure sufficient drop through regulators at each base position to get good regulation.

Figure 13 — The equipment shown will give proper distribution of atmosphere to several bases.



A UNIVERSAL ANNEALING FURNACE

Omitting stainless steels from consideration it will be noted throughout the discussion of various applications, that atmosphere 1a can readily be applied to wide range of annealing processes and both low and high carbon steels, and silicon steels.

The idealized atmosphere for a wide range of steel annealing applications would be one to meet the following requirements:

1. Low in cost.
2. Generated from readily available fuel gases.
3. Relatively inert, no combustion hazard.
4. Non-oxidizing.
5. Non-decarburizing.
6. Chemically active enough to overcome oxygen, impurities but inert enough with slow reaction rates to eliminate sooting and etching throughout the entire annealing temperature range.

Atmosphere 1a with ratio of fuel to air adjusted to give around 3 to 4 per cent CO and corresponding hydrogen content comes very close to fulfilling all of the above requirements. The principal purpose of this paper was to summarize developments in applications of controlled atmospheres. From this survey it would appear that atmosphere 1a offers promise of much wider use in annealing applications for a wide range of steels. It can serve as an excellent "base" gas atmosphere for a wide range of annealing applications in various phases of the steel industry. It appears that new developments in applications will tend to center around use of this type of "base" gas with minor modifications or additions of other gases to make it suitable for specific process applications.

DISCUSSION

PRESENTED BY

ARTHUR S. MERROW, JR., Senior Engineer, Combustion Department, Bethlehem Steel Co., Lackawanna, N. Y.

GEORGE J. CAMPBELL, Assistant Fuel Engineer, Bethlehem Steel Co., Sparrows Point, Md.

J. L. KOZMA, Lee Wilson Engineering Co., Inc., Cleveland, Ohio.

NORMAN B. JONES, Section Engineer, Industrial Heating Engineering Division, General Electric Co., Schenectady, N. Y.

C. E. PECK, Manager, Industrial Heating Engineering, Westinghouse Electric Corp., Meadville, Pa.

Arthur S. Merrow, Jr.: At the Lackawanna plant we have thirteen of these atmosphere gas generating units, ten of them conventional units supplying a gas with an analysis of 5.5 per cent CO_2 and 8 per cent CO, and a dew point of 42 F. We have three of the generating units classed as 1a which is completely burnt gas with the CO_2 being removed in auxiliary stripping equipment, and an electrodryer giving a dewpoint of—50 F. These are located in our new bar annealing department.

Three of our carbottom annealing furnaces are equipped for natural gas enrichment of the atmosphere gas. I wonder if you have had any experience with this enrichment? If so, what applications does it have in the annealing of bar steel?

George J. Campbell: The steel industry's largest tonnage of annealed steel is cold strip annealing of sheets and cold strip annealing of tin plate. This tonnage falls in a low carbon group which should require the simplest of all atmospheric applications. Because of the large tonnage involved, it follows therefore that it is of the greatest concern to a higher percentage of individuals using prepared atmospheres. As pointed out the application should be simple and the problems few. However, there are still a few problems left, and I would like to ask Mr. Peck what his experience has been on the following: Coil strip and flat annealed sheets — the strip is rolled in the cold mill with either mineral oil or sperm oil. It is not scrubbed but is annealed with small amounts of residual oil present. The result is a soft light soot deposit on the outer wraps and near the edges of the inner wraps. The prepared atmosphere is similar to No. 2 or 5½ per cent CO_2, 8½ per cent CO, 13 per cent hydrogen and the balance nitrogen, the mixture having a dew point of 54 F.

Will some other prepared atmosphere clear up this sooty condition especially on the inner wraps at the edges?

I would like to point out that we are using special large atmosphere gas lines to these inner covers, however, our aim is not to use more, but less prepared atmosphere. We would like to change our gas composition in order to correct the condition.

With cold strip tin and black plate, using the same prepared atmosphere as noted above, no particular problem exists as to brightness or appearance of anneal. However, the industry is concerned with edge-center-edge corrosion resistance of tin plate. The variation from center to edge of tin plate, both hot dipped and electrolytic, is attributed to the prepared atmosphere used in annealing coils.

The question is what kind of prepared atmosphere will eliminate or even partially correct edge center edge corrosion of tin plate? What has been Mr. Peck's experience along this line and what results based on prune tests have been accomplished so far?

J. L. Kozma: I agree with Mr. Peck on his points of operating practice and wish to state that our operating experience indicates that correct rates of gas flow and proper inner cover pressures above atmospheric, to reduce oxygen diffusion, is of great importance in operating practice, particularly in the annealing of high carbon and alloy steels, in order to eliminate surface decarburization.

Our experience also has been that in the annealing of high carbon or alloy steel material, liquid seal inner covers are preferred rather than sand seal covers, as with a liquid seal inner cover, atmosphere loss and air infiltration inward through the seal is prevented. On our circular bell type furnaces the sealing liquid is a high flash point oil, which is cooled by means of recirculating water in an adjacent channel seal.

On our liquid seal furnaces an internal pressure of about 0.5 in. water column is maintained by means of a reduced pipe section on the end of the atmosphere discharge pipe from the annealing base. A fixed orifice discharge area of this type provides consistent internal pressures on all charges annealed, providing that the inlet gas flow is constant. However, on sand sealed inner covers in many cases most of the atmosphere gas is discharged or circulated through the sand seal as Mr. Peck stated.

Since it is impossible to pile the sand to uniform height on each and every charge, and the care exercised by the various operators in sealing the inner cover differs, the internal pressures vary. Under these conditions consistency in results is impossible.

I can add that atmospheres of the inert types listed in the paper also have applications to be used as a carrier gas in such processes as carbon restoration or skin recovery. These processes are now being carried on commercially by a few manufacturers in their annealing process. The carrier gas in this process is enriched with one of the hydrocarbon gases to provide a carbon balance suitable to restore the carbon in the existing decarburized surface areas. The gas in this application is higher in carbon potential than that required for decarb free annealing.

The control and operation of the gas generating and furnace equipment in the carbon restoration process is similar in most respects to that of the annealing process. Experimental development of the carbon restoration process has been carried on by us and others in this field of endeavor. Results obtained indicate very successful possibilities for the process.

I would like to ask if there are any rule of thumb formulas used in determining combustion chamber

lengths for gas generators, possibly in respect to diameters? How important is chamber length and type of catalyst used in order to complete combustion reactions within the chamber?

What noticeable effects, if any, might be observed on steel being bright annealed and slow cooled to low temperatures, if the gas generator supplying the gas should be found too short in length, although chamber temperatures of 2000 to 2200 F are maintained?

Norman B. Jones: A new development is the combination equipment consisting of the atmosphere converter and the CO_2 remover equipment all combined in one unit which is sent out complete from the factory piped and wired, ready for water and electrical connections to be made in the field. The CO_2 boiler is incorporated as part of the combustion converter and acts as a recuperator and as a cooling means for the combustion converter.

C. E. Peck: Mr. Merrow asks a question concerning enrichment of the atmosphere gas with natural gas, and applications in the annealing of bar steel. The necessity for and the amount of enrichment to prevent or control decarburization depends on the type of carrier gas atmosphere and furnace used.

For example using conventional combusted atmosphere designated in the paper as No. 2 in a sand seal type cover furnace, the approximate amount of enrichment necessary when annealing some medium carbon alloy bar stock at 1450 F to prevent decarburization was 20 to 25 per cent by volume of natural gas. In this case, the interior of the furnace around the charge becomes a secondary gas reaction chamber and the gas composition and dew points tend toward a composition which is in equilibrium with the carbon content of the steel. Use of this carrier gas which in itself is decarburizing to the medium and high carbon steels is not desirable, since enrichment is large in amount and secondary gas reactions in the furnace cause very unstable conditions resulting in variable results on the steel as soon as one variable in the process is changed only slightly.

A better answer is to use a non-decarburizing neutral gas atmosphere such as 1a and enrich it with a small amount of hydrocarbon gas. (This method is also mentioned by Mr. Kozma in his discussion.) In this case using a furnace where the atmosphere can be reasonably maintained the amount of hydrocarbon enrichment can be limited usually to a value of from 3 to 5 per cent of the volume rate of gas atmosphere make-up to the furnace. Such a practice in general should prevent decarburization of bar stock in long cycle annealing using cover type furnaces or properly sealed car bottom furnaces.

Mr. Campbell raises some questions on control of soot deposit on cold rolled strip steel during annealing. Soft light soot on the outer wraps of the coil could be due to an intergas reaction where the metal surface acts as a catalyst to partially decompose CO into CO_2 and free carbon. This reaction takes place during the slow cooling of large batches of steel, particularly at temperatures of 1000 to 1100 F and is accelerated when the dew point of the atmosphere is relatively low. This same phenomena can occur to a limited extent at the edges of the wraps of the coil.

In other words, it is possible to get a light soot deposit on the steel from carbon resulting from gas reaction even though the steel itself is perfectly clean going into the furnace.

In general, carbon deposit from either the sperm or mineral oil which is in the pores of the sheet steel from the cold rolling process will not cause soot deposition on the steel, if sufficient gas atmosphere is used during the early stages of the heating up cycle to thoroughly sweep out all of the oil vapor as it comes off and before the steel reaches temperatures of 800 to 1000 F.

Since Mr. Campbell points out that their practice leans toward using ample gas, it would appear that soot deposition could be due principally to gas reaction rather than oil. To remedy this, the air gas ratio of the generator should be adjusted to a little lower value of CO and H_2 while maintaining the same dew point of the atmosphere.

Concerning Mr. Campbell's question on atmospheres suitable for annealing tin plate to eliminate or minimize variations in edge to center corrosion resistance, practical results indicate that the CO_2 free dry neutral, high nitrogen gas classified as 1a in the paper does a better job than the conventional reducing atmosphere No. 2. One of the discussers enlarged on this in his verbal comments by stating that in addition they took steps to remove the small amounts of CO so that fundamentally the best atmosphere was a dry nitrogen hydrogen mixture with nitrogen the predominant element, and sufficient hydrogen (5 to 10 per cent) to insure good reducing properties and eliminate any oxidation. Such an atmosphere can be produced also by burning dissociated ammonia but when large quantities of gas are used, the special treatment of fuel gas sources provides a cheaper source of the nitrogen hydrogen mixture. The fundamental atmosphere for this application appears to be one containing no oxidizing or carbon bearing components in the gas. This means that H_2O, CO_2 and CO should be taken out of the gas. Although the equipment required to produce such a gas is much more elaborate and expensive than the type used for the production of more conventional reducing gas mixtures, it is apparently justified for large scale tonnage batch annealing of tin plate using present furnace equipment and processing methods.

Mr. Kozma asks some questions on proportions of gas generators. In general for the generators used to make a reducing gas such as atmosphere No. 2, a reaction time of 2 to 3 seconds should be allowed in the generator and an efficient catalyst such as nickel impregnated refractory should be used to insure complete reaction to give maximum H_2 and CO.

On gas generators, which operate at all times at lean ratios, the use of a catalyst is not necessary, but use of broken refractory pieces in the combustion chamber is desirable to completely mix and react with any trace oxygen.

If the generator is too short from the stand point of reaction time and catalyst, then the resultant gas contains excess free methane and is not reacted with available oxygen in the generator. Such a gas can promote soot deposition on the steel or in extreme cases there is possibility of trace oxygen which would discolor the steel.

LUBRICATION OF

. . . . lubrication of a modern rolling mill is a complex problem, and the various components of the mill each require their own system designed for the lubrication problem which must be overcome . . . .

▲THE problem of lubrication as applied to the industry has become more complex and important wi h the advances made in production equipment and methods.

The rolling mill itself, whether a single or multiple stand installation, has probably, from a lubrication standpoint shown the greatest improvement in design, construction, and operation. It is actually the key to production and as such must produce a product continuously to very close tolerances. To accomplish this the designers and builders have developed the modern rolling mill as we know it today. This accomplishment is the combined effort of the operators and the manufacturers of the component parts that go to make up a complete rolling mill. Throughout all of the development work, lubrication has played a most important part. This fact can be recognized by the changes made in the design and construction of the reduction gears and pinion stands. The open gear drives of the older mills have been totally enclosed in order to provide a continuous supply of lubricant and thus minimize wear and cool the bearings and gears. The oil-film type of roll-neck bearing introduced to the industry was made possible by providing positive means for maintaining a constant supply of oil for lubrication and cooling.

Circulation oiling and centralized pressure grease systems have been developed to replace manual application and to provide a continuous supply of lubricant to all moving parts. Consequently the lubrication systems are as much a part of the rolling mill assembly as any of the mechanical parts, and therefore require specialized attention to assure trouble-free operation. Oil, when used as a lubricant, serves the dual purpose of providing lubrication and is a medium for carrying away the heat developed during the rolling operations. Grease fundamentally serves the single function of providing lubrication.

Lubrication and rolling mill maintenance are so closely allied that in the study of the problems involved it should be considered necesssary to correlate maintenance work in the analyses of lubrication results. The relationship between maintenance and lubrication costs has no particular significance because, for the most part, maintenance costs are so much greater than the cost of lubricants that it is practically impossible to interpret one in terms of the other. However, the type of maintenance necessary is important and should be analyzed from the lubrication standpoint.

In the selection of the lubricants, recommendations are interpreted first in terms of physical analyses. This provides the operating personnel with information necessary to assure them that the oil viscosity or grease consistency is within the range needed to lubricate the equipment involved. There are, however, the influences of certain operating factors on the lubricant that actually dictate the selection of the product to be used. Probably the most important of these operating factors are speeds, temperatures, loading, contamination, and consumption.

The primary purpose of a lubricant is to reduce friction between moving parts in order to minimize wear and permit continuous operation. In reducing friction, metallic friction is replaced by fluid friction and the heat developed in overcoming this friction affects the operating temperature of the lubricant.

In considering the results obtained in problem analyses, it is seldom that complete lubrication failures occur. This condition would probably be due only to stoppage of the lubricant to the bearings or gears involved and would manifest itself in a very short time as an excessive temperature rise, in a matter of minutes, and would be followed very shortly by equipment failure. The majority of lubrication problems are the result of what might be considered partial lubrication failure. Such failures will not in most cases become evident immediately, but require considerable time before the effects are noticed. A thorough understanding of what happens to the lubricant in service and an intelligent interpretation of the changes from the original characteristics of the lubricant will indicate, long before actual mechanical failures occur, whether lubrication is satisfactory. When oil is used, its condition and changes in characteristics should be observed closely from the time a new charge starts in service. However, when large capacity systems are involved, six months to a year, or longer, may elapse before any conclusive evidence will become apparent.

Several separate circulation oiling systems, requiring different types of oil, are necessary to lubricate adequately the present day rolling mill. The mill driving motor and motor-generator sets are lubricated either from a central system or from the pedestal reservoir of each bearing. The volume of oil for these applications is usually large but the consumption will be small. Oil leakage at the bearings must be eliminated to prevent damage to the windings. All of this equipment is located or equipped to operate in a clean atmosphere. The motor-generator sets and, in some cases, the mill driving motors are installed in separate rooms where the ventilating air is kept clean.

The oil for this application is, due to the location of the equipment, not subject to any unusual contamination. Therefore, operating temperature is the major factor influencing changes in lubricant characteristics. First indications that changes are taking place in the oil are shown by an increase in neutralization number, darkening in color, and increase in viscosity, followed later by sludging. All of these changes are the result of oil oxidation, the rate of which increases at elevated temperatures. The major portion of oil circulating through the bearings acts to keep them at a uniform temperature. The bearing outlet oil or reservoir temper-

Presented before AISE Annual Convention, Pittsburgh, Pa., September 25, 1947

ROLLING MILLS

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ature will be influenced by speed, temperature of the journal, and localized hot spots, and will be somewhat lower than some of the spot temperatures to which the oil is subjected. The oil selected for this application should be well refined turbine-oil type with long life characteristics. When the oil first goes into service it is advisable to make frequent analyses in order to observe the changes taking place. Any unusual increase in neutralization number, or darkening in color, will generally indicate an abnormal temperature some place in the system which should be located and corrected as soon as possible. The amount and nature of sediment are of importance during the initial stages of operation. Any material other than atmospheric dirt would probably be bearing metal and would indicate a misfit bearing. Later the sediment would show evidence of deposit forming sludges.

If a circulation system is equipped with continuous filtering equipment, the amount of sediment should show little tendency to increase. However, on those systems not so equipped the amount of sediment shown by analysis will be helpful in determining when the oil should be taken out of service for filtering to remove the accumulated dirt.

The reduction gears and pinion stands present another lubrication problem. These units may be separate or combined together in a single gear case. In some few cases, the pinions are driven directly from the motors with no intermediate reduction gears. In general, these units are lubricated from circulation systems.

The loading on reduction gears is usually not as heavy as that on the pinion stand gears. Also, the shock load from the mill is absorbed through the pinion stand gears and coupling which reduces the effect of that load on the reduction gears. The selection of the lubricant for these units lies basically between a straight mineral oil or a high-film-strength type of lubricant. The choice generally speaking is made on the basis of gear-tooth loading.

There does not seem to be any clear cut dividing line from a loading standpoint between where a high-film-strength lubricant should replace a straight mineral oil. However in general, reduction gears can be lubricated satisfactorily with oils that do not contain film-strength additives, whereas pinion stands need the high-film-strength lubricant.

There are a number of advantages in selecting an oil that does not contain high-film-strength materials, the principal one being to reduce the amount of maintenance necessary to keep the oil in serviceable condition. High-film-strength characteristics are obtained by incorporating materials into an oil. These materials by nature do not improve stability properties.

Selection of the viscosity necessary for a particular application is made initially on the basis of experience, taking into account speeds and ambient temperatures. In gear lubrication, it is desirable to maintain the highest viscosity possible at the lowest possible operating temperatures. Induced heat and continuous circulation and churning of the lubricant in the gear case will, because of the internal friction of the oil, tend to increase its operating temperature until a more or less balanced condition is reached. Consequently, high viscosity products will operate at higher temperatures. As the operating temperature increases, the rate at which the lubricant tends to oxidize also increases, with resulting increase in viscosity and operating temperatures. Thus a vicious cycle is created. Here again, the changes in the lubricant characteristics do not take place immediately. Therefore if proper observations are made from the time a lubricant first goes into service, the operating characteristics of the system will indicate whether the correct selection has been made.

Periodic examination of the gear teeth, starting after the initial run-in period, will indicate whether there is excessive wear, metallurgical defects, or misalinement. Misalinement is one of the most common causes of gear troubles encountered in mill operation. When this occurs the load will only be carried on a portion of the gear teeth. In examining the gear teeth, the heavily loaded area can be identified before any destructive wear occurs. Usually this area first becomes evident as a bright spot above or below the pitch line at one end on the load side of the tooth. This bright spot will fade away to a dull appearance over the remaining tooth length. In extreme cases of misalinement, a similar bright area will be evidenced on the back side of the tooth at the opposite end from the spot on the load side of the tooth. Excessive wear, metallurgical defects, or misalinement can be corrected if analyzed properly at the start.

The operating temperature and the change in viscosity over a period of time are the principal factors to consider in determining whether the original viscosity is correct. In practically all cases, the temperature of the lubricant leaving the gear case will be higher than the entering temperature. This difference in temperature should remain fairly constant except as influenced by changes in surrounding atmospheric temperatures. If however over a period of time the temperature difference increases, a corresponding increase in viscosity can be expected to continue and can best be corrected by dropping below the viscosity of the original product, thus reducing the effect of internal friction on oil temperature.

Oils in gear systems will, in most cases, be subject to more dirt contamination than the motor bearing system. Consequently more attention should be given to the accumulation of sediment which, if found to be increasing, will indicate that the oil should be filtered for dirt removal. These systems are seldom subject to water contamination, consequently there will be no emulsion problems. Often visual inspections of the oil, supplemented by laboratory analysis, and an examination of gears and gear cases for deposits are sufficient.

when compared with previous inspections and analyses to determine whether the changes taking place are abnormally rapid.

Service evaluation of changes in high-film-strength lubricants are more difficult to analyze. Usually the products are black or very dark in color which makes it impossible to make any significant visual inspection. The composition of the product is such that the neutralization number will have little meaning. Therefore, the important tests to consider are viscosity, film strength, sediment, and nature of sediment. There are, however, certain operating factors which are fair indications of the changes taking place in the lubricant. The operating temperature and temperature increase have been mentioned. In nearly all cases, systems using this type of lubricant are equipped with filters. Substantial increase in pressure drop across the filter is most likely due to an excessive accumulation of dirt or sludge. By observing the filter operation, the frequency of cleaning, and type of material removed from the filter a reasonable analysis of the changes taking place can be made.

In some few cases, pinion stand systems may be subject to water contamination. Although such occasions are rare, it should be recognized as a possible problem and the necessary procedures established to determine when contamination with water occurs. In general, methods for determining the presence of moisture in lubricating oils are relatively simple and do not require the services of highly trained technicians in making the determinations. This particular phase of the contamination problem will be discussed more in detail later in connection with oil film bearing systems.

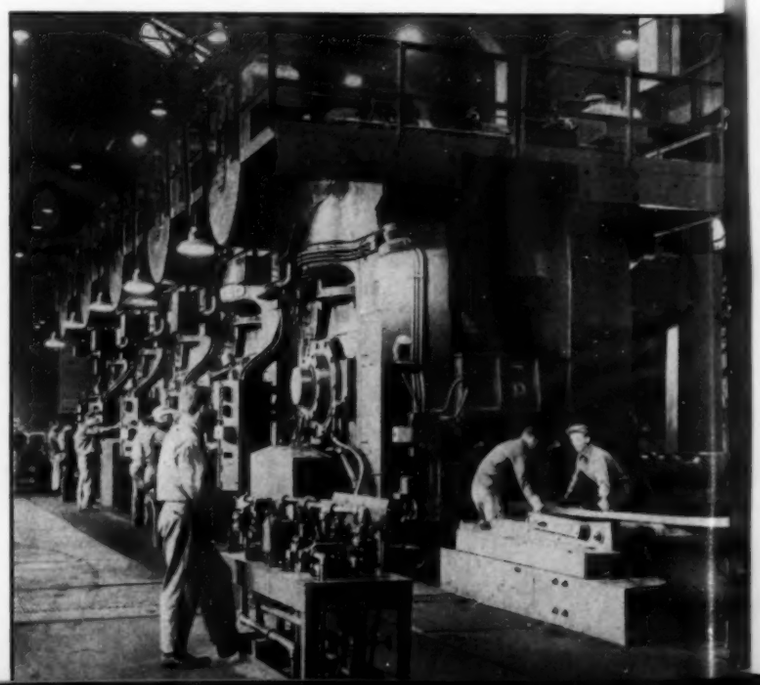
Screw-down drives in modern rolling mills are designed for bath or circulation oiling, and the trend now is toward the use of products similar to those used in pinion systems. Roll pressure adjustment is often necessary during mill operation, thus causing a difficult and heavily loaded condition on the gear teeth. The gear movement is slow and the travel, when adjustment is made during operation, is very short.

The oil film type of bearing used extensively for roll-neck bearings presents an interesting and critical lubrication problem. The oil serves as a lubricant for the bearings and as a medium for carrying away the heat developed during the rolling operation. The bearings are designed and constructed so that there always is a constant supply of oil available to provide full fluid film lubrication while the rolls are turning. Oil pockets or reservoirs are machined into the bearing bushing and are always full of oil. Practically all of the oil entering the bearing passes through these pockets or reservoirs as it circulates through and around the bushing for cooling purposes.

The actual lubrication of the bearing is relatively simple since, as stated before, a positive supply of lubricant is always available; however, when the mill is started from standstill, the bearings actually are operating under conditions which approach boundary lubrication until the fluid film is established. The start-up period is, from a lubrication standpoint, the most critical. There have been occasions where bearings removed from the rolls have shown evidence of wiping, but with no indication of when that wiping occurred or that it had interfered with operation. If there is no increase in operating temperatures, it is quite possible that this wiping may have occurred when the mill was started with an excessive screw pressure which would produce deformation of the bearing metal similar to that produced in the actual cold-rolling process.

Since the oil used to lubricate the bearing also acts to cool it, it must of necessity not deteriorate in service to a point where sludge or deposits are left in the passages provided for circulation through the bearing. On mills using water as a roll coolant, the bearing oils are subject to water contamination. Both types of oil flooded bearings include in the assembly seals to control both water and oil leakage. However, at times regardless of the care taken in the bearing assembly when rolls are changed, water will leak past the seals into the system. Continuous circulation of the oil and contaminating water through the system will eventually result in the formation of persistent types of emulsions. If the water leak is not corrected or means taken to remove the water from the system, either periodically or continuously, inadequate lubrication and cooling will result. It is, as stated before, an easy matter to detect the presence of water in the oils used for the oil film type of bearing. These oils are, for the most part, transparent; however, when contaminated with water they will become quite cloudy, turning to a decided yellow color as emulsification progresses. The color change does not indicate the actual quantity of water in the oil. Furthermore, high-film-strength lubricants in the majority of cases will show little or no change in color even when contaminated with a large percentage of water. However, it is relatively easy to measure the quantity of water present. The test described in the standard ASTM procedure can be made by any oil-system attendant, the results comparing favorably with those obtained by any skilled laboratory technician. This is one of the few tests which the oil-system attendants can make regularly without leaving their posts, thus giving them a check on a particular type of contamination which may be constantly changing and

The development of the modern high speed tandem mills was largely dependent upon development of adequate lubrication systems.



which may reach emergency proportions in a few hours' time. There are cases when water removal from the oil can be accomplished without too much difficulty. The usual procedure is to heat the oil in an idle tank to approximately 180 F and hold it at that temperature for several hours, then, with the heat shut off, the oil is allowed to cool and settle. Separated water can be drained from the bottom of the tank. There are times, however, when this procedure will not effectively break the emulsion and water will not settle out. When this condition develops, it is necessary to add material to assist in breaking the emulsion. There are several of these materials available that give satisfactory results. In general, they are added after the oil in the system becomes emulsified. There is no substantiating evidence that these materials added to the oil before emulsification are of any particular benefit.

Materials to assist in breaking the emulsion should usually be added three or four hours previous to the mill shutdown so that it will be thoroughly mixed with the oil in the system. This is necessary since the quantity added is very small, ranging between 0.10 to 0.25 per cent. This material can be added in a number of places in the system; however, the most effective places will be either through the return line at one of the bearings or through the priming point on the main oil circulating pump. Emulsions formed in the system are complicated in nature, but from the standpoint of operating personnel, it is not necessary to go into all details of the mechanics and chemistry of the emulsions. The emulsions formed result from the fact that oil, water, and various types of emulsifying materials are mixed together through the pumps, valves, bearings, etc. Emulsifying materials are finely divided dirt and steel particles, products of oil oxidation, and reaction products resulting from products of oil oxidation and solid contamination in the oil. Considerable progress has been made by the petroleum industry in reducing the products of oil oxidation which promote emulsion formations in the system. This has been done without affecting the essential characteristics of the oil either as a lubricant or as a cooling medium.

In addition to the equipment lubricated from circulation systems, there are also a number of applications requiring grease lubrication. The centralized-pressure grease systems, both manual and automatic, have been developed to the point where grease can be supplied to various bearing surfaces at a controlled rate approximating that obtained with circulation systems. Unlike circulation system lubrication, the grease dissipates little or no heat. The grease at times is subject to contamination of water, dirt, roll coolant, and steel dust. The operating conditions and contamination are determining factors in the frequency with which grease must be applied to bearings. Here again, the lubricant itself will, if properly examined, indicate whether the lubrication as applied is adequate. If the temperature is high enough to soften the grease to a thin fluid state, it is necessary to apply the grease more frequently and in larger quantities or change the type of grease used. If solid contamination is excessive, the grease in the bearing will tend to stiffen considerably. If this condition develops, a laboratory analysis is necessary to determine the cause of stiffening. If it is solid contamination, the ash content will be quite high and an examination of the ash will show evidence of iron oxide and bearing metals.

There are many other points on a rolling mill assembly which are important from a lubrication standpoint. However, the paper just presented has been confined to applications which the author believes best illustrate the complexity of the problem. An attempt has been made, in a limited time, to show the factors which influence the selection of products and the importance of properly interpreting the changes taking place in the lubricants as they continue in service.

DISCUSSION

PRESENTED BY

LEO TACHOIR, District Engineer, Tide Water Associated Oil Co., Pittsburgh, Pa.

L. E. LOVITT, Socony-Vacuum Oil Co., Inc., Pittsburgh District, McKees Rocks, Pa.

C. E. PRITCHARD, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio

T. R. MOXLEY, Superintendent of Maintenance, Wheeling Steel Corp., Steubenville, Ohio

WILLIAM H. MANDY, Lubrication Engineer, Texas Co., Pittsburgh, Pa.

Leo Tachoir: Mr. Lovitt said it is desirable to use an extreme-pressure lubricant in pinion stands. I think we all agree, but has he ever determined the load on these mill pinion teeth? Second, has he ever determined the shock load value on these pinion teeth? Third, has he ever encountered load pressures that were in excess of the protection offered by extreme-pressure lubricants?

L. E. Lovitt: There have been many calculations made on loading gear teeth. This loading varies over quite a wide range, based either on actual mill loads or rated motor loads. To the best of my knowledge, the loads have not exceeded the range of the extreme-pressure lubricants.

Leo Tachoir: Have you ever determined some actual value?

L. E. Lovitt: One of the highest that I have encountered is about 9000 lb per inch of face.

Leo Tachoir: An extreme-pressure lubricant is not considered an extreme-pressure lubricant until it takes about 33,000 psi, and that being the case, if you have encountered only about 9000 psi. This is well under the range of an extreme-pressure lubricant, is that not right?

L. E. Lovitt: The calculated load was about 9000 lb per inch of face. But to determine the unit loading it is necessary to know or estimate the contact area. I mentioned the case of misalinement. There are cases where gears have operated under misalinement conditions where the load is carried on less than one-quarter of the full tooth face and lubricated satisfactorily with straight mineral oil.

Member: Can you give us some idea of the relative values of what we have come to classify as conventional extreme-pressure lubricants for industrial use; for example, in pinion gear sets and the new all-purpose or universal gear lubricants which have appeared since the war and which conform to Government Specification 2-105B? I find an increasing interest in the universal extreme-pressure gear lubricants and am wondering if this formula actually represents an improvement over the fluid type extreme-pressure lubricant which has been in use for many years?

L. E. Lovitt: I do not believe I can give you very much on that, because right at the moment I do not recall the details of Specification 2-105B.

Member: I think without reference to the specification, we know that it is a stronger extreme-pressure base. The question asks whether or not a stronger extreme-pressure lubricant is necessary, or are the conventional types sufficient for present equipment?

L. E. Lovitt: For the most part the conventional types of lubricants have been satisfactory for the majority of applications. I do not recall offhand any application in steel mills where a more active type of extreme-pressure lubricant is required. There are a few probably, but, in general, the conventional type of extreme-pressure lubricants are satisfactory.

Member: Would an extreme-pressure lubricant protect the gears during that run-in period? I do not think from a pure lubrication standpoint that it would, because that stream of cold working is taking place which causes the minute parts to spall out. After that as we all know in most cases fortunately the spalling stops or the small particles stop coming out of the gears and they may run for many years after that without further loss of metal. Some of these extreme-pressure lubricants do have qualities which may protect the surface chemical, and if that is the case they might prevent that original spalling of the metal, and we know we would all rather have a gear set which does not have those pockmarks in the faces of the teeth than a gear set which does have those pockmarked faces, because even though more metal does not spall out of those spots or out of the other spots, there must be an actual loss of contact area and further wear is certainly more apt to develop, even though it does not take place for several years.

I do not know whether you can answer my question or not but I will try to sum it up again. Does the extreme-pressure lubricant protect the metal chemically, or is it a physical phenomenon? In other words, does it prevent original corrosion?

L. E. Lovitt: In general we have two classifications of extreme-pressure lubricants. One has no effect on the actual metal surface itself, and chemically deposited surface is put on the gear teeth actually from operation itself. There are changes that take place in the lubricant that place a protecting film on the teeth.

The other general classification is one that is chemically active with the gear teeth material and probably a sulphide surface is developed on the gear teeth surfaces. In one case you have, theoretically, no actual wear of the gear teeth, and in the other case you have controlled wear.

C. E. Pritchard: We have experienced some tearing or pitting on the surface of the gear teeth of unlapped pinions subjected to heavy duty service operation. This condition, we believe, has resulted because of the presence of localized high spots on the mating surfaces, causing local hot spots with incipient seizure to take place. Hand grinding of these spots during the initial run-in period generally prevents any further progressive pitting of the tooth surfaces. Some added benefits might be obtained in these cases by increasing the extreme pressure qualities of the lubricant. However for other than these abnormal conditions the general purpose mild extreme-pressure type lubricants suffice in every respect.

T. R. Moxley: We master mechanics and maintenance men can do more to defeat the purpose of the lubricating engineer than anyone else. A great number of us still have the main bearing type of gear drive. The more modern type of antifriction bearings are fixed so you cannot change them; they are fixed and you cannot move them. But all you have to do is be a little bit negligent in the maintenance of the bearings in which these gears operate and the teeth will go bad fast, and the first thought is: "That lubricant is no good."

I can frankly say that I have never had a lubricating problem that was not solvable if the equipment was right. There is only one thing I want to ask: "Why do you not do something about being able to put breaker in the oil to reduce the water as it accumulates, and not wait until it gets up to 5, 6, or 7 per cent and then take it out. Whenever this can be done, that is going to help considerably on mills where there is water contamination.

With a new bearing, where the seals are all in perfect condition, they will keep the oil out for a while, but eventually they wear a little bit, and water will creep in. Then, unless somebody is on the job, you have anywhere from 5 to 10 per cent of water in the circulating system before you know it. So, if and when the day approaches when breaker can be built in this oil so that water will drop out quickly, it will be of great benefit in keeping water contamination out of these oils.

Maybe everyone does not have the same problems that we have. We have the oldest wide strip mill there is in the United States at Wheeling Steel. When that mill was built, the spindles between the pinions and the work rolls were the old convention four-wobbler type. They were not the universal spindles that we have today. Consequently, the mill was designed with the pinions close to the roll stands. Eventually when we increased the speed of the mill and put in new gear drives some years ago, the center distance of the brass slippers on the spindles is only 33 in. You can appreciate the amount of misalinement we have with a new pair of rolls in this mill. Naturally, with the rpm that these last three stands of the mill operate, we cannot hold lubricant satisfactorily in those spindles. We wrap them with leather, burlap, paper, and many other items, but due to the velocity of the revolution of that spindle, we cannot hold lubricant in the slipper brasses, as we call them. Of course, the manufacturer of these spindles has provided in the design ways and means for lubricating them, but you cannot shut them down every thirty minutes and pump lubricant into them. You have to keep them running. That is something to think

about: Give us a lubricant that will stay on, so that the centrifugal force will not throw it off.

Mr. Lovitt spoke about practically all of the motor rooms being air-conditioned. Why should you have contamination in the bearings of machines in such locations?

L. E. Lovitt: As a rule, you do not have. The major problem, fundamentally, is one of sludging over a long period of time.

T. R. Moxley: The only sludging problem we have is in the circulating systems where water is the chief cause.

L. E. Lovitt: Your sludge there is an emulsion, but over a period of time, with increased temperature sludge-forming materials will build up in an oil. The oils designed for that particular application have been refined to a point where they form a minimum of these sludges.

T. R. Moxley: What is the foreign material that enters the bearing, and what can we do about keeping it out to prevent sludging? In other words, you say that the lubricant is built to withstand that.

L. E. Lovitt: It is not the foreign materials that form the sludge but the products of oxidation that develop in the oil. The foreign materials contaminating the oil, however, may act as catalysts to increase the rate of oil oxidation. You will notice, if you have sludging, a varnish or lacquer-like deposit in the bearing cap, reservoirs, sides of the bearings, and so forth.

T. R. Moxley: Then continuous filtration would not take it out? In other words, in practically all circulating systems today you have built in with that system a continuous filtering system. Should not this filtering system be adequate to take out this sludge?

L. E. Lovitt: No. Some of the first sludge-forming materials are soluble in the oil at the operating temperature.

T. R. Moxley: You could not take it out by filtering; it takes temperature to drop it out?

L. E. Lovitt: It can be taken out by the activated earth-type filters. They will remove those materials.

T. R. Moxley: My experience with these activated earth-type filters is that if you use them for the purpose of taking out sludge you will also take out your extreme-pressure quality material.

L. E. Lovitt: With an additive oil, part of the additive is removed.

T. R. Moxley: Then that would not do any good.

L. E. Lovitt: That is a debatable subject. In the activated earth type of filter, the amount of products of oxidation and additives that are removed is a direct function of the ratio of clay or activated earth to the quantity of oil passing through the filter. After that clay becomes saturated, it is no longer active in removing products of oxidation, and then acts as a mechanical filter—a very good mechanical filter—because you have very small openings for the oil to go through and it will remove very fine solid contamination. In order to remove products of oxidation, it is necessary, in an activated earth type of filter, to replace the cartridges or the earth frequently.

T. R. Moxley: We do not have too much trouble with that; but anyway you make us a grease that will stay on the spindles. That will at least solve one problem that is troublesome at present.

William H. Mandy: Mr. Lovitt mentioned the importance of giving lubrication systems specialized attention to assure trouble-free operation. This applies to grease systems and oil systems. I should like to elaborate on the benefits to be obtained by proper operation of the oil system.

In starting a new system, I think it is important to operate the centrifuge almost continuously over the first few weeks of operation to rid the system of dirt and fine particles of pipe scale and rust formed during the construction of the mill. Contaminants can be removed from the oil even though the system was flushed out with a flushing oil before the lubricating oil was installed.

In this connection, I think most oil cellars are not properly ventilated. Those that I have been in, have been humid; they are running at a temperature of 115 to 120 F and I think some step should be taken in the design of this equipment to put a more adequate ventilating system in the oil basements.

Also, I do not think it would be amiss to ventilate the tops of the settling tanks. You heat the oil up to around 180 F the water vapors come off the oil and hit the top of the tank and condense there. They not only rust the inside surfaces of your tanks but later, the free water drops right back into the oil. I think some design whereby the tanks themselves could be ventilated, even to the extent of installing a suction fan pulling this humid atmosphere not only out of the tanks but out of the basement would be helpful.

I am a firm advocate of painting the inside of the tanks (which is not often done) with some oil-resistant paint or oil insoluble rustproof compound of some kind. If you inspect the inside of the tank, especially the top, you will often find rust sometimes a quarter of an inch thick which falls off in flakes. Of course, your pressure filters take most of this out, but a lot of it settles to the bottom and acts as a catalyst to make the emulsion that much more difficult to break.

When we start these grease systems, we should change the line strainers at least once a week for several months. I have seen strainer baskets completely filled, even to the extent that the finely meshed strainers were broken. An inspection of the strainers revealed that they were filled with dirt and pipe-scale from the grease lines. I think the solution to Mr. Moxley's problem is probably to change to an R and O type oil. Our experience is that we have not had any particular trouble with such systems. The only water to contend with is from condensation. Since the equipment is installed in an air-conditioned room, I do not think these oil systems on motors and motor-generator sets should present much of a problem.

The big problem is in our hot strip mills where we have so much water to contend with. It is apparently impossible to prevent water from getting into the bearings, so it is up to the oil manufacturers and the oil equipment manufacturers to design systems and products that will more easily drop out the water before the oil becomes emulsified. I think centrifuging is desirable under certain conditions. I think the proper batch settling of the oil is very desirable early in the game; do not wait until the oil reaches a stable emulsion. Get the water out just as soon after it gets in as possible.

Electrical Equipment for Cold Strip Mill
AT GREAT LAKES STEEL

. . . . at the time this paper was presented the mill described was under construction, it has since been completed and is now in operation . . . .

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▲PROBABLY the most outstanding advance in cold rolling during the past few years has been the greatly increased speed at which the strip is finished. It was not many years ago that 1000 fpm was considered a high finishing speed. There are, however, mills now in operation which run as high as 5000-6000 fpm finishing speeds. While these extremely high-speed mills are intended primarily for rolling tin plate stock, there has been a corresponding advance in the technique of rolling wider and heavier strip, and the new mills for this type of material now involve correspondingly increased speeds.

The new unit at Great Lakes Steel Corporation is a 93 in., 3-stand, tandem cold mill with a maximum finishing speed of 1600 fpm, and includes all modern features in electrical equipment and control.

It is the purpose of this paper to describe briefly the electric equipment and general arrangement of this mill, together with some of the more interesting control and application problems which were encountered.

MILL EQUIPMENT

The mill consists of three four-high stands and winding reel with work rolls 21 in. diameter by 93 in. wide, and back-up rolls 53 in. in diameter. The mill housings are among the largest in cross-sectional area which have ever been built in order to withstand the tremendous forces required for rolling such wide material.

Each mill stand is driven by a 4000-hp, 750 v, d-c motor. The motor for stand No. 1 is a single armature unit rated 80/200 rpm. Stand No. 2 motor is a double armature unit rated 100/250 rpm, and the motor for stand No. 3 is also a double-armature unit rated 116/290 rpm. These ratings are considerably greater than are used for any similar mill now installed or contemplated at this time. All three stand motors are direct-connected to the rolls through pinion stands so the rolls rotate at the same speed as the motors.

The winding reel is driven by an 800-hp, single armature motor rated 150/525 rpm, 600 v. This motor drives through a gear unit having a ratio of 2.25:1.

POWER SUPPLY

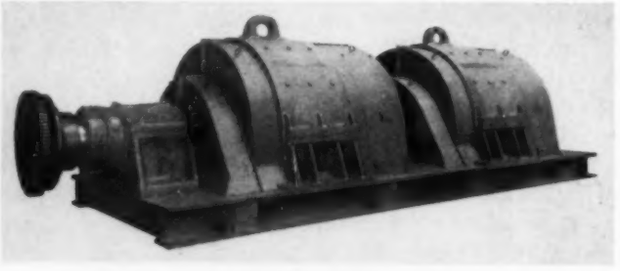
The power for the operation of this mill is supplied by the Detroit Edison Company at 6600 v, 3-phase, 60 cycles. An 11,200-kw motor-generator set converts this power to direct current for the operation of the mill and reel motors. This set consists of the following machines:

3- 3500-kw, 750-v d-c generators, one for each stand motor.
1- 700-kw, 600-v generator, for the winding reel.
1- 14,000 hp, 0.9 pf, 360 rpm, 6600 v, 3-phase, 60-cycle, synchronous driving motor.

The five units constituting this set are mounted on a common fabricated steel base, forming a set approximately 56 ft long, 14½ ft wide, and 12½ ft high. In power rating, this is one of the largest, if not the largest, motor-generator sets which has ever been built.

The stand motors are rated on a 40 C rise continuous, forced ventilated basis, while the motor-generator set is rated on a 40 C rise continuous open basis. The motor-generator set, as well as the motors, is arranged for forced ventilation.

Figure 1 — Because of the low moment of inertia double armature mill motors are used in steel mill service to provide better acceleration characteristics. The unit illustrated is a 3000-hp, 750-volt with interchangeable rotors consisting of two 1500-hp, 400/700-rpm, 750-v motors.



Presented before AISE Detroit District Section Meeting, April 8, 1947

REDUCED INRUSH CURRENT

The inrush current when starting such a large motor-generator set is apt to cause severe voltage surges in the power system. It is, therefore, advisable to take steps to keep the inrush current within reasonable limits. To accomplish this, the set is started at reduced voltage by means of a reactor and, in addition, high-pressure oil pumps are provided, one for each bearing, to force oil into the bearings before starting the set. This greatly reduced the breakaway torque and permits starting at a lower voltage than could otherwise be used. Provision is made for automatically stopping the high-pressure pumps after the set has come up to speed.

POWER FACTOR REGULATOR

The load on the synchronous motor of the main motor-generator set is necessarily of a fluctuating nature, due to the rolling cycle. If the field of the synchronous motor was continuously excited at the value required for the maximum load condition, it would mean that under light load conditions, the reactive kva developed would be excessive, and this would result in objectionable variation in the voltage of the 6600-v system.

In order to overcome this condition so far as possible, a power factor regulator is provided which controls the field of the synchronous motor in proportion to the load within certain limits. As the load on the synchronous motor increases, the field will be automatically strengthened and, as the load falls off, the field will be correspondingly weakened to a predetermined minimum value. This regulator is so arranged that it may be adjusted to hold either power factor or reactive kva at any predetermined value within the capacity of the equipment.

INDIVIDUAL GENERATORS

One of the new and novel features of modern tandem cold mill practice which has been incorporated in this mill is the use of individual generators, wherein a separate generator is used to supply power to each mill stand motor and to the reel motor. This feature has many advantages. Booster generators for each mill stand can be eliminated since, with a separate generator for each stand, the control of the motor armature voltage, as well as compensation for IR drop in the armature circuit, can be incorporated in the control of the generator itself, without the use of an additional booster.

The connections between the generator and motor armatures are greatly simplified, since the connections of each drive can be carried directly from the generator to the motor through the necessary circuit breakers and line switches, thus eliminating the need for heavy buses which are required when generators are operated in parallel.

The speed cone of the mill is widened out at the lower limits, since any stand motor may be operated below its

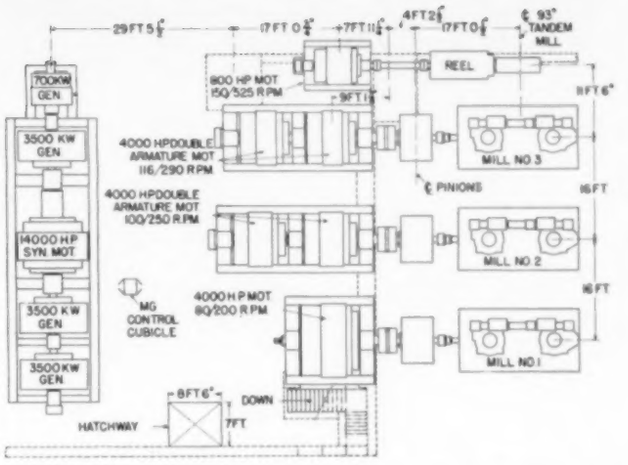


Figure 2 — General arrangement of mill and main drive electric equipment.

base speed by means of voltage control. This is not possible when generators are operated in parallel.

The short-circuit duty of the main generator circuit breakers will be reduced since each main generator will be isolated from the others. This also means that mechanical bracing of all main leads need not be as great as with the conventional system.

The elimination of a booster set not only simplifies the connections and control, but also actually results in a considerable saving in space. It also follows that maintenance expense will be reduced because of the fewer number of rotating machines.

DOUBLE ARMATURE MOTORS

In any high-speed mill, it is desirable to keep the inertia of the rotating equipment as low as possible and also the inertias of the various stands should be balanced as closely as possible. Mills of this type are accelerated under full rolling load, so the motors must carry not only the rolling load but must also provide the power required to accelerate the rotating equipment. The inertia of the motor armature is a large proportion of the total inertia of each drive. Therefore, any reduction which can be made in the Wk^2 of the motor armature means almost a proportional reduction in the accelerating current, and a very material reduction in motor heating. Furthermore, the higher inertias the greater is the possibility for unbalance among the various stands with subsequent effect on the tension and gage during acceleration or retardation.

In order to keep the inertia of the last two stands which are the higher speed stands as low as possible, the motors are of the double-unit type consisting essentially of two motors of the same rating, mechanically coupled together and mounted on a common base. The Wk^2 of the double-unit motors is approximately 40 per cent of what it would be if single armature motors were used. The Wk^2 of stand No. 2 motor is approximately 200,000 lb ft^2 whereas a single-armature motor of the same rating would have a Wk^2 of approximately 500,000 lb ft^2. A corresponding ratio exists for the No. 3 stand motor. Figure 1 shows the arrangement and gen-

eral appearance of a double-armature motor similar to those which will be used in the present case.

LAYOUT

This mill is to be installed in an existing building, and it was therefore necessary to adapt the layout to existing conditions insofar as possible. Frequently, in a new mill of this type, a separate motor room is provided in which the electrical equipment is located and which is entirely shut off from the mill to exclude mill vapors, dust, and other foreign material which might be detrimental to the electric equipment. In the present case, however, it was not possible to provide such a motor room and the main motor-generator set and the mill driving motors are, therefore, located in the mill area. The control equipment, auxiliary motor-generator sets, etc., are located in a basement which is separate from the mill area. Figure 2 shows the general layout of the equipment on the mill floor.

It, therefore, became necessary to provide ventilating systems for the main motor-generator set and main mill motors to provide adequate cooling and to keep the equipment under a slightly positive air pressure.

The arrangement finally selected for ventilating these machines involves the use of a fan and cooler for each unit of the driving motors and each d-c generator.

The coolers and fans are located directly beneath the machines and air barriers are so arranged that the warm air from the machine is discharged downward at the commutator end, where it passes through the surface air coolers and fans and is delivered into the basement and back to the machine at the coupling end, thus providing a separate recirculating system for each armature unit. Figure 3 shows schematically the arrangement of fans and coolers for the No. 3 stand motor.

It was not feasible to install a separate fan and cooler beneath the reel motor, so the ventilation of this motor is combined with that of the No. 2 unit of stand No. 3 motor. The warm air from the reel motor is discharged downward at the commutator end and delivered through a duct into the discharge chamber for the No. 2 armature of stand No. 3, whence it passes through the coolers and fans and back to the coupling end of the reel motor, the same as for the main drive machines. This accounts for the use of two cooler sections for the No. 2 armature of stand No. 3 motor, whereas only a single cooler unit is used for each of the other armatures of the driving motors.

The ventilation of the generators of the motor-generator set is practically identical with that of the fan motors. A separate fan and cooler for each generator are installed underneath the machines, and the circulation of air is exactly the same as for the motors.

The synchronous motor of the set has sufficient fan action to ventilate itself, so no external fan is required. For this machine, a cooler is installed directly beneath the machine, where the warm air is discharged through an opening in the frame. This air, after passing through the cooler, is returned to the motor at either end by means of the fan action of the motor itself.

Usually, where a recirculating ventilation system, such as employed in the present case, is used, it is necessary to install a make-up air fan and filter to provide a supply of clean air to make up for any leakage in the ventilating system and also to maintain the entire system at a slightly positive pressure to exclude dirt and dust, vapors, etc. In the case of the Great Lakes mill, there is already available an adequate supply of filtered air, so no additional make-up equipment is required. This make-up air will be delivered to the basement and, since the ventilating systems of the motors and motor-generator set are also open to the basement on the cool-air side, it is apparent that the entire basement and ventilating system will be kept at a slightly positive air pressure as determined by the pressure of the make-up air.

The auxiliary motor-generator sets which are installed in the basement are all open, self-ventilated machines, so it was necessary to make the coolers of the ventilating system large enough to take care of not only the losses in the main machines but also those of the auxiliary equipment and control apparatus.

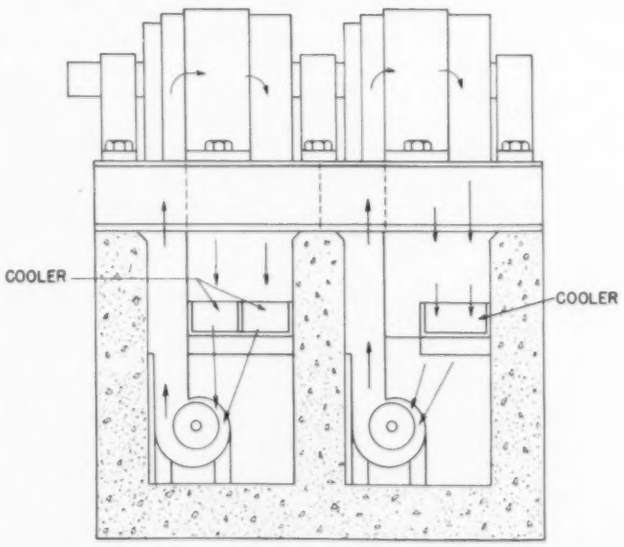
TENSIOMETERS

Aside from the screws, the only means of controlling gage electrically is by means of tension in the strip. It is, therefore, highly desirable that the operator have a means of knowing what the tension is in the strip at all times so he may use tension to the fullest extent and yet not exceed the allowable stresses in the material. For this purpose, the mill is equipped with two double-ended tensiometers, one installed between stands No. 1 and 2 and the other between stands No. 2 and 3. These tensiometers measure and give a continuous indication of the tension in the strip. These tensiometers are purely indicating devices and no attempt is made to automatically hold tension or gage. They simply provide a means of measuring the tension and leave it to the good judgment of the operator as to what the tension should be.

CONTROL OF OFF-GAGE MATERIAL

The control of off-gage and scrap material from a mill of this type is a very complex subject and we can, there-

Figure 3 — Schematic arrangement of ventilating system for No. 3 stand motor.



fore, touch on it only briefly here. The success of any mill is determined by the amount of saleable output it produces. It is therefore, essential that the equipment be laid out to provide a high rate of production of quality strip with a minimum of scrap and off-gage material.

A large proportion of the off-gage material is produced while threading the mill and operating at low speed. It is, therefore, of prime importance that the mill be so arranged that it can be accelerated and retarded in the shortest possible time and so the strip can be brought on gage at the earliest possible moment while accelerating, and be kept on gage as long as possible when decelerating.

The use of double-armature motors on stands No. 2 and 3, together with the proper balancing of inertias and the refinements in the control equipment, should go far toward reducing off-gage material to a minimum.

It is planned to accelerate this mill in approximately six seconds from threading speed to full speed. If a mill is accelerated at a uniform rate, the amount of strip passing through while accelerating from half speed to full speed is three times the amount which passes through while accelerating from zero to half speed. Therefore, if the strip can be brought on-gage at, say, 50 per cent speed, it is apparent that the off-gage material will be comparatively small.

It should be noted, however, that there are many causes contributing to off-gage material which cannot be corrected by the electric equipment. Among these are variations in gage of the incoming hot strip, the shape of the rolls, the lubricating and cooling arrangement and last, but not least, the rolling technique. No matter how fine the electric equipment may be, it cannot compensate for such features. It is true, however, that if the electric equipment is properly laid out and coordinated, it will make it easier for the operator to keep the off-gage material to a minimum; while on the other hand, if the electric equipment is improperly laid out, it can largely counteract an otherwise perfect mill and skillful operation.

The combined effect of all causes contributing to gage variation is radically different during acceleration or deceleration as compared to steady-state running conditions. When a mill is running at constant speed, it is comparatively easy to hold gage by making minor adjustments in the tension or by an occasional slight movement of the screws.

The problem of holding gage while the mill is being accelerated or decelerated is much more difficult. It is a well-known fact that the gage will vary with the speed, all other factors remaining the same. If a mill is set up to give a certain gage at a certain speed, and the speed is then changed without changing any other condition, the gage will also change. If the speed is increased, the gage will become less. If the speed is decreased, the gage will become heavier. It, therefore, follows that if the tension is increased as the speed is decreased, it will be in the direction to counteract the natural tendency toward heavier gage. However, if this increase in tension is carried too far, it may cause breakage, especially if the strip is brittle or has badly cracked edges.

It is here that the tensiometers are of greatest service as they give a continuous indication of the tension so the operator can make the maximum possible use of tension in holding gage and yet keep within the breaking strength of the strip.

CONTROL

The general scheme of generator voltage control and speed control of the mill motors is the same as in many existing mills. The mill is accelerated and retarded by generator voltage control, and the individual speeds of the motors adjusted by field control. There are, however, several new features incorporated in this mill in line with modern practice, which are worthy of mention.

Figure 4 shows an elementary diagram of the field and essential control circuits for stand No. 3 and the reel. The controls for stands No. 1 and 2 are very similar to that for stand No. 3.

Since individual generators are used, it is necessary that a means be provided for holding the voltages of all generators in a certain definite relationship, one with the other, as the mill is accelerated or retarded, as well as under steady state running conditions. To accomplish this, there is provided a pilot generator which supplies fixed reference voltage against which the voltage of each generator is compared. One dial of a potentiometer type motor operated rheostat is connected across the pilot generator and provides a means of selecting any portion of the pilot generator voltage, from zero to 750 v, as the reference voltage against which these generator voltages are compared.

A generator field exciter of conventional design is provided which supplies the nominal field excitation for the three main generators. The field of this exciter is controlled by a dial of the potentiometer rheostat, so the voltage of the exciter will build up at approximately the same rate as the reference voltage and the fields of the main generators will likewise be built up at approximately equal rates.

In order to overcome any variations in the rate of voltage buildup of the main generators, a rotating regulator type counter emf exciter is connected in series with each generator field. The function of this machine is to buck or boost the excitation voltage supplied by

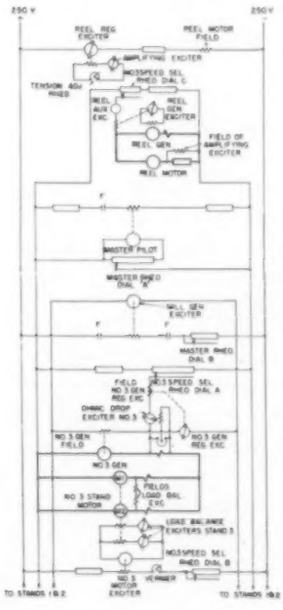


Figure 4 — A schematic control diagram for No. 3 stand and reel is given in this drawing.

the generator exciter as may be required to hold the generator voltages in the desired relationship with the reference voltage. The control fields of the counter emf machine are balanced between the reference voltage and the voltage of the main generator in each case, so current will flow through this field in one direction or the other, depending on whether the voltage of the main generator is higher or lower than the reference voltage. This constitutes a voltage regulating means by which the voltages of the main generators are always held in some predetermined ratios with the voltage of the pilot generator.

The control of motor speed, as mentioned before, is partly by generator voltage control and partly by motor field control. A speed selector rheostat is provided for each stand drive. These are equipped with two dials, one of which is connected as a potentiometer across the pilot generator and determines at what voltage the main generator will operate, while the other dial is used to control the field strength of the main stand motor. These two dials are so arranged that the motor field cannot be weakened until the generators are operating at full voltage, thus preventing operation with low generator voltage and weak motor field.

The question of compensating for ohmic drop and its effect in the operation of the mill is also a very involved subject and can be considered only briefly. If a motor had no internal resistance and there was no line drop, its speed would always be proportional to the applied voltage, (except for the slight demagnetizing effect of the load current). However, since motors do have internal resistance and since there is always some line drop, the speeds of the motors will tend to lag behind the voltage by an amount proportional to the total resistance in the armature circuit and the load which the motor is carrying.

Since the resistance of the armature circuit of the various motors is likely to differ, and since the per cent load carried by the motors may be different, the speeds of the various motors will depart from the theoretical value by differing amounts.

It, therefore, becomes advisable to introduce into the control a means for compensating in part at least for this ohmic drop effect. To accomplish this, a rotating regulator type exciter is introduced into the field circuit of the counter emf exciter which controls the generator voltage. The field of this ohmic drop machine is in effect connected across the commutating and pole face windings of the main generator so that the output voltage of the ohmic drop machine is a direct function of the load carried by the generators, and this will bias the voltage of the counter emf machines, and hence the main generators as well, by an amount proportional to the load.

It has been found by experience that it is not possible to operate a mill with complete ohmic drop compensation since this would result in a very "stiff" mill and excessive tension in the strip as the mill was slowed down. Partial compensation for ohmic drop is, however, a very valuable feature in getting the mill on gage sooner when accelerating and keeping it on gage longer when retarding. Provision is made for adjusting the amount of ohmic drop compensation to any desired value, or it can be cut out entirely if the operator so desires.

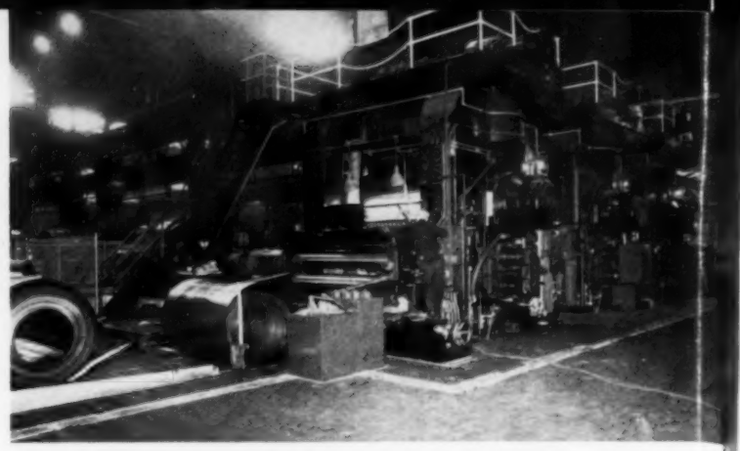


Figure 5 — The mill was installed ready for operation in December 1947.

When two motors are mechanically coupled together, driving any load, it is very improbable that they will divide the load equally between them due to minor variations in motor characteristics. It is, therefore, necessary to provide a means for maintaining a substantially equal division of loads between the two units of the double armature motors. To accomplish this, a rotating regulator type load balance exciter is connected in series with the field of each motor unit. This exciter will buck or boost the excitation voltage supplied by the motor field exciter, by an amount necessary to maintain equal division of load. The control fields of these load balance machines are connected in series across the commutating and pole face windings of the two motors in such a way that if one motor tends to take more than its share of the load, its field will be strengthened and the field of the other unit weakened, until load balance is restored. This feature is entirely automatic and, when once properly adjusted will maintain equal division of load between the two armatures under all operating conditions.

The control of the reel generator voltage is practically the same as for the main generators. The principal difference is that since there is only one generator involved, the rotating regulator type exciter is used to excite the field of the reel generator direct instead of as a counter emf exciter, as in the case of the main genrators. The field of the reel exciter is balanced between the reference voltage and the voltage of the reel generator in the same manner as for the main generators, so the voltage of the reel generator is held in a prede-

Figure 6 — The control and instrument panels are installed in the basement and copper bar connections are used between the generators and motors overhead.

termined relationship with the voltage of the pilot generator.

Tension in the strip, between the No. 3 stand and the reel is regulated through the means of an amplifying exciter which controls the field of a counter emf machine in series with the field of the reel motor.

The field of the amplifying exciter is connected across a resistor in the armature circuit of the reel motor so the output voltage of the amplifying exciter, as well as the voltage of the counter emf machine is a function of the reel motor armature current.

A tension adjusting rheostat, available to the mill operator, is provided by which the tension in the strip can be adjusted to any desired value, within the capacity of the equipment.

The tension in the strip is held at the pre-selected value within a very small margin at any speed, and throughout the buildup of the coil.

An auxiliary exciter is connected in series with the field of the reel generator exciter in the same manner as the ohmic drop exciters are used for the main drives. This auxiliary exciter not only provides ohmic drop compensation for the reel, but also furnishes excitation to the reel generator exciter, when the mill is at rest, thus making it possible to maintain stalled tension if the mill is brought to rest with strip in the rolls and on the reel.

This auxiliary exciter also provides a means for forcing the reel generator when accelerating or retarding to compensate for the effect of Wk^2 and assist the tension regulator in maintaining constant tension.

DISCUSSION

PRESENTED BY

J. A. SHIMMIN, Plant Engineer, Rotary Electric Steel Co., Detroit, Mich.

F. R. GRANT, General Electric Co., Schenectady, N. Y.

W. A. MOSTELLER, Application Engineer, General Electric Co., Detroit, Mich.

L. R. MILBURN, Chief, Korean Power Mission, Seoul, Korea. (Formerly Electrical Engineer, Great Lakes Steel Corp.)

PAUL STEED, Westinghouse Electric Corp., Detroit, Mich.

C. E. S. EDDIE, Assistant Superintendent, Steam and Fuel Department, Great Lakes Steel Corp., Ecorse, Mich.

H. W. ARAUZ, Minneapolis-Honeywell Regulator Co., Brown Instrument Division, Detroit, Mich.

L. A. UMANSKY, Assistant Manager, Industrial Engineering Divisions, General Electric Co., Schenectady, N. Y.

J. A. Shimmin: How do you intend to start the 14,000 hp motor?

F. R. Grant: It is started at reduced voltage by means of a neutral reactor. Power is applied with the reactor in series and when the motor has reached a certain predetermined speed, this reactor is short circuited, field applied, and the motor put on the line. It is a typical synchronous motor starter in a 14,000 hp size.

Member: How long does it require to have the motor come to full speed?

F. R. Grant: I do not have definite figures on that, but I would imagine the motor would come up to speed in about a minute, or a minute and a half. It comes up to speed pretty quickly. Having the shaft floated in oil, in the bearings, helps greatly in getting the motor started and up to speed.

W. A. Mosteller: What is the weight of the coil that is to be rolled on this mill?

L. R. Milburn: The maximum coil to be rolled on this mill is 25 tons. The maximum outside diameter of any coil will be 72 in., and the inside diameter will be 28 in.

W. A. Mosteller: On the cabinet, there are two stop buttons, emergency stop and regular stop. Will you please explain when they are used?

F. R. Grant: The regular stop is used normally when bringing the mill down to rest. Under any emergency condition the emergency button would be used. The emergency stop operates directly to de-energize the generator field and set up dynamic braking. The regular stop button brings the mill to rest by causing the master rheostat to go to the zero voltage position thus gradually reducing the generator voltage.

W. A. Mosteller: Is that regenerative braking?

F. R. Grant: I should have said regenerative braking. The only time the motors are disconnected from the generators is in a true emergency stop, not from the pushbutton, but due to overload or some real emergency condition in the operation of the mill. The motors are then disconnected from the generators and dynamic braking applied.

W. E. Brennan: What is the kva inrush at the starting?

F. R. Grant: Full voltage kva inrush is about four and a half times normal kva rating. Actual kva inrush, of course, would be determined by the tap used on the reactor, and I do not know just what that will be. It will probably be in the neighborhood of a 25 per cent tap.

I might say that a considerable number of rolling schedules were calculated to determine the power required and the rating of the motors. We figured rolling schedules starting at 0.115 and finishing at 0.075 in.; starting at 0.125 and finishing at 0.06 in.; starting at 0.112 and finishing 0.048 in.; starting at 0.093 and finishing 0.036 in.; starting at 0.078 and finishing 0.031 in.; starting at 0.063 and finishing 0.024 in.; and those schedules were figured for both 48 in. wide strip and 90 in. wide strip, and the equipment finally selected is suitable for those schedules. Of course, for the 90 in. wide strip the speeds are lower than for the narrower strip.

Paul Steed: Do you recall the tension between stands that we figured on?

F. R. Grant: We figured on 20,000 psi between stands No. 1 and 2, and 25,000 psi between stands No. 2 and 3, between stand No. 3 and the reel I think we figured around 8,000 psi tension.

C. E. S. Eddie: On your low speed you brought out the fact that you had enlarged the cone. Would you have any idea what proportion of the cone was on low speed?

F. R. Grant: You can drop down to about 50 per cent of the base speed of the motor. With 21 in. rolls, for stand No. 1 the minimum speed is 438 fpm and the top speed 1100 fpm. For stand No. 2 the minimum speed is

549 fpm and the top speed 1370 fpm, and for stand No. 3 the minimum speed is 638 fpm and the top speed is 1597, or 1600 fpm. Those are at the rated speeds of the motors. Now, these lower speeds can be dropped 50 per cent by means of voltage control. So that would give you, on stand No. 3, a minimum speed of about 320 fpm, or an available speed range of 320 fpm minimum to 1600 fpm maximum. Corresponding reductions can be obtained on the second and first stands.

H. W. Arauz: Mr. Grant, you mentioned you use an increased oil bearing pressure on starting. Is that to float the rotor of this motor?

F. R. Grant: Yes.

H. W. Arauz: Is this bearing pressure continued through the entire operation?

F. R. Grant: No. I should have mentioned that it is arranged so that as soon as the speed comes up to the point where the reactor breaker closes, the oil pumps are automatically shut down. The high pressure lubrication is only on when the set is starting and coming up to speed.

H. W. Arauz: Does it require any particular features in the design of these bearings?

F. R. Grant: No, not that I know of. We simply pump oil into the bottom of the bearing to force it in between the shaft and the bearing, because when a rotor of that weight sets in the bearing any length of time, practically all of the oil is squeezed out from between the shaft and the bearing and you practically have metal to metal contact.

Member: What is the principle of the tensiometer; is it more or less a simple strain gage, or does it work on a pressure principle?

F. R. Grant: It consists of a roller mounted on springs with the strip passing over the roller, and as the tension increases it depresses the roller and that motion is transmitted to an adjustable air gap transformer. The output of that transformer is proportional to the air gap, so that as the tension increases and the roller is pressed down, it changes the air gap giving a greater output from the transformer. The transformer output is rectified and used to operate the meter. It is very similar to a strain gage.

C. E. S. Eddie: What oil pressure do you develop on the pump, and how do you maintain control?

F. R. Grant: I do not know exactly the pressures used here. I think they are in the neighborhood of 1500 psi. We simply use a little motor driven positive displacement pump to pump oil into each bearing. There is no controlling system involved, it just pumps a certain amount of oil into the bearing and it flows out around the shaft.

C. E. S. Eddie: Does the mill operator control the pump before he controls the mill operation?

F. R. Grant: Yes, the pumps have to be started before he can start the set, which is interlocked through the starters for the pumps. The pumps have to be running before he can start the set.

C. E. S. Eddie: It must be an oil-sealed bearing to do any good then?

F. R. Grant: The oil is introduced into the bottom and at about the center of the bearing, so the oil has to flow through the bearing and out at the ends. And in doing that it floats the shaft.

C. E. S. Eddie: It is very evident that you do not have any seal on these bearings at all.

F. R. Grant: No seal other than an oil deflector to keep oil from being thrown out of the bearing when the set is running, because this forced lubrication simply forces oil into the bearing and it flows through the bearing and back into the pedestal. It is forced in under the shaft and in order to get out of the bearing it has to flow under and around the shaft and in so doing it lifts the shaft to break it loose from the bearing.

L. A. Umansky: A description of a complex electric equipment such as needed for operating a modern cold strip mill well illustrates the point that the art of rolling could not have reached its full development if it were not for electrical engineering. The latter provides not only the "brawn" but also the "brains" for a mill of this type. The functions of an electrician really overlap those of the roller; both should understand and appreciate each other's problems.

With reference to some questions raised, I want to point out that the high pressure oil system for starting heavy rotating machinery is not new in industry. As the size of electric equipment in steel mills increases, the use of this type of lubrication is gaining popularity. Its advantages are obvious.

A large motor-generator, of the size described by Mr. Grant, but equipped only with conventional bearing lubrication, would require, for instance, a torque of 17 per cent normal to break away from rest. To provide such torque not less than 37.5 per cent voltage should be applied to the motor and this would result in a 135 per cent starting current. To make certain that the set will start even when the supply voltage is below normal, a higher voltage tap is usually employed, resulting in a still higher starting current.

By employing high pressure oil pumps (say 1500 psi) for the bearings of the set, the weight of the rotating members is lifted and an oil film is formed between the shaft and the journals. This may cut down the starting torque requirements in the ratio of almost 4:1. A lower voltage tap can then be used for starting. In case of reactor starting, the current drawn from the line is then reduced almost in half.

The 1500 psi oil pressure at the pump outlet drops after the set begins to rotate and the oil pressure is practically zero at the points where the oil leaves the bearing linings and returns to the reservoir. The bearings are, of course, designed to prevent the oil from leaking to the outside.

This method of starting has been used very widely, for instance, with large synchronous condensers on power transmission lines, with large frequency changers used by utilities, steel mills, and the like. An 8000 kw. motor-generator set at the cold mill of Carnegie-Illinois Steel Corp., Irvin works, was also equipped in similar fashion, and for the same purpose.

Another point can be well emphasized. Reference was made by Mr. Grant to the tensiometers with which this mill will be equipped. It might be of interest to this group that the first installation of these devices was made at Detroit on the 56 in., 3-stand tandem mill of the Ford Motor Co. Two of them were ordered in 1934, installed a year later, and are still used to good advantage on that mill, as on some other 130 installations.

DEVELOPMENTS IN CONTINUOUS

Butt Weld Pipe Mills

. . . . modern butt weld tube mills now under construction will have speeds up to 1000 fpm, and have as many as twelve stands . . . .

By WILLIAM RODDER

Vice President in Charge of Engineering

The Aetna-Standard Engineering Co.

Youngstown, Ohio

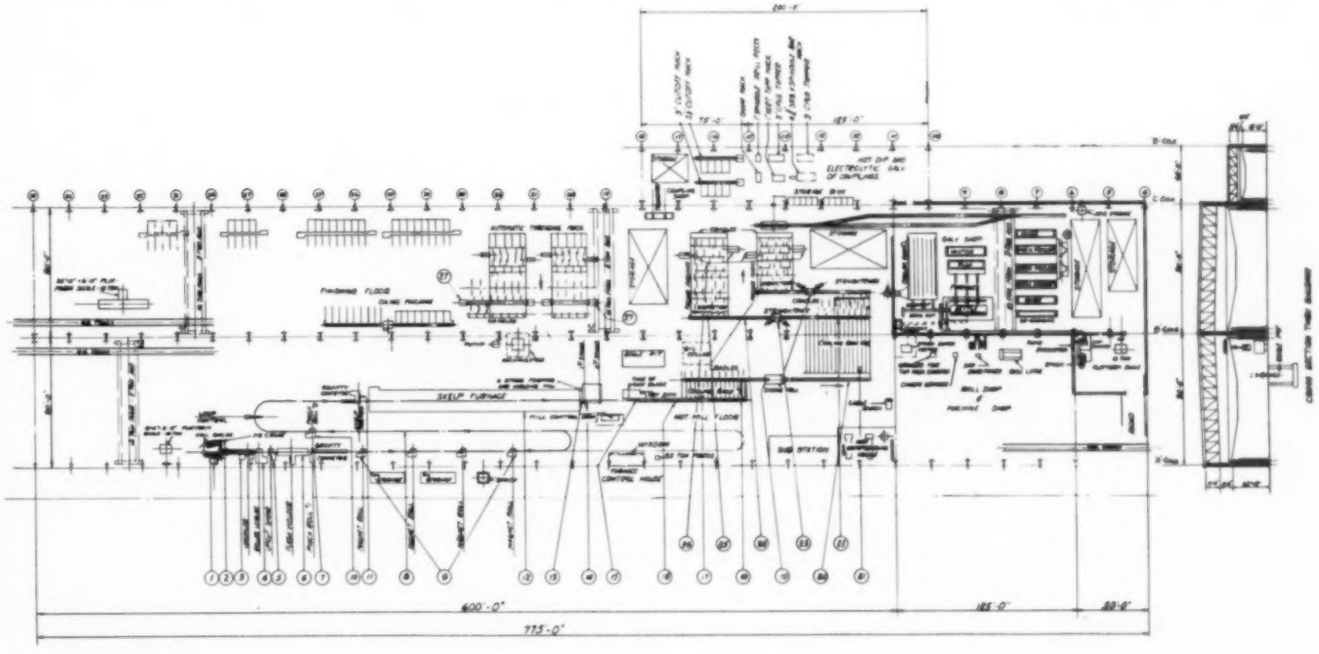
▲ SEVERAL papers have been presented to the Association of Iron and Steel Engineers in the past describing the early stages and developments of the continuous butt weld pipe mills, or as called by its inventors, "The Fretz-Moon Pipe Mill."

This paper will primarily deal with recent developments. Figure 1 illustrates a modern plant layout of a continuous butt weld pipe mill, including finishing floor and galvanizing plant (capacity of this mill—½ to 4 in. pipe, maximum speed 500 fpm). The mill consists of the following units:

1. Coil storage racks.
2. Jib crane for unloading coil to uncoiler.
3. Uncoiler—used for unwinding coil and feeding skelp into roller leveller for flattening.
4. Roller leveller.
5. Shear—used for squaring ends if necessary.
6. Flash welder—used for butt welding coils together.
7. Pinch roll No. 1—used for positioning of leaving coil end in flashwelder.
8. Skelp loop—provides sufficient skelp storage to assure continuous operation of mill while uncoiling unit is stopped and front end and trailing end of two coils are welded together in flashwelder.
9. Magnet roll units—assist leveller in feeding skelp into storage loop.
10. Pinch roll No. 2—pulls skelp out of storage loop and feeds it into skelp heating furnace.
11. Furnace threading machine — used for feeding skelp through furnace at initial starting of mill.
12. Skelp heating furnace—heats the skelp to a temperature of approximately 2450 F.
13. Blow nozzles—located at delivery end of furnace just ahead of forming pass. The purpose of these nozzles is to blow air of 1.5 psi pressure against the skelp edges which increases edge temperature from about 2450 to 2600 F. Capacity of blower is about 4000 cu ft per min.
14. Forming and welding mill—the heart of the continuous butt weld pipe mill, the same as the piercing mill is for a seamless tube mill. The operation of this mill is of the utmost importance—as good or

Presented before AISE Annual Convention, Cleveland, Ohio, October 1, 1948

Figure 1 — Shown here is a typical layout for a continuous butt weld pipe mill for producing ½ to 4 in. pipe.



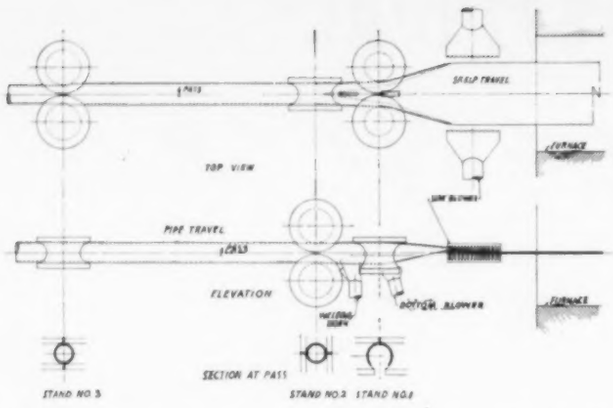
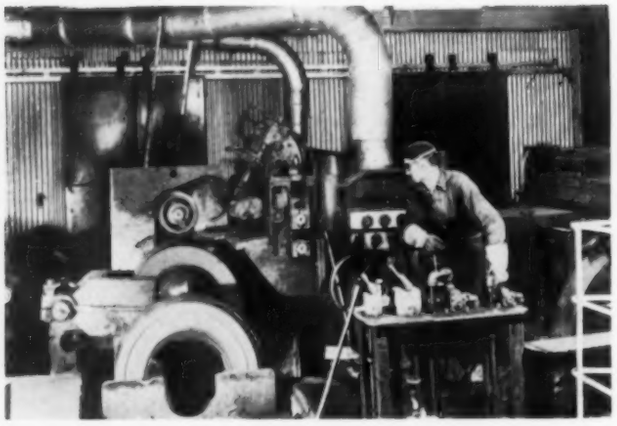


Figure 2 — The arrangement for the forming, welding and reducing operations is given in this drawing.

Figure 3 — The mandrel type uncoiler is very suitable for the skelp size used in making 1¼ to 4 in. pipe.



poor pipe is made here which cannot be changed in the further process.

In pass No. 1, called forming pass, skelp is formed into a circle approximately 270 degrees closed. In pass No. 2, called welding pass, skelp edges are squeezed together, sufficient reduction must be provided in this pass to form a good weld. Good welding practice shows a reduction in welding pass of 4 to 6 per cent. It is a standard practice to use a skelp with a bevel edge, see Figure 9.

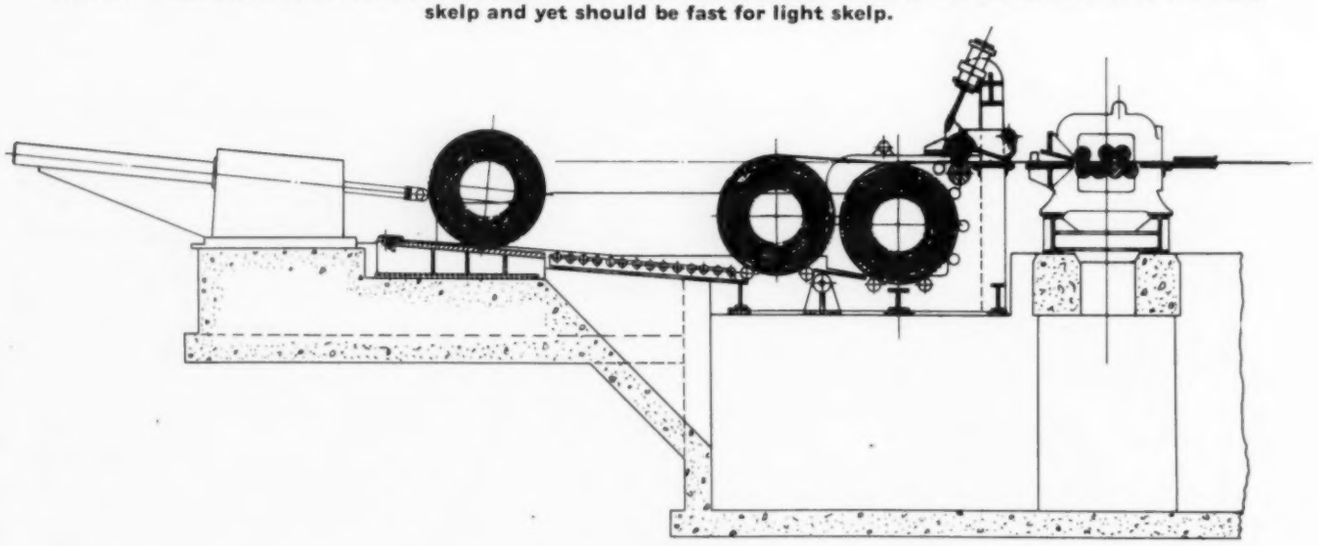
The condition of edge is very important for obtaining a good weld and not leaving a seam on the inside or outside of the pipe. Good welds and pipe have been produced with skelp having a square edge, but round edges are very detrimental for obtaining good welds.

The question arises quite often as to whether slit strip can be used for the making of good pipe. Slit strips have been used successfully and can be used for making standard and extra heavy pipe ½ to 4 in., provided that the edges are sound, that is, the segregation originating in the ingot has not been brought into the open by the slitting operation. If slit strip is to be used in the making of the steel, elimination of all segregation before rolling of the wide strip is a must. However, if this has not been done the result will be an improper weld and large amounts of scrap pipe.

Figure 2 illustrates the forming, welding, and reducing of the pipe, also the shape of passes in the mill. It will be noted that the formed pipe goes into the welding pass in a downward curve, this bending of formed pipe helps to bring the edges together before the squeezing is done in the welding pass. The so-called "welding horn" located between the forming pass and the welding pass keeps the formed pipe in proper position relative to the welding pass. It is required when making pipe sizes 1¼ in. and up. Smaller pipe sizes can be made without the welding horn. The welding horn is cooled by air or water. Between the forming pass and the welding pass is also located a small air nozzle to blow compressed air of about 20 psi against the edges to again increase the temperature of edges. This air blast at the same time helps in freeing the edges from scale. Oxygen has also been used experimentally ahead of the welding pass for improving the weld and increasing the speed of the mill. After the welding pass, further reduction passes are provided to reduce the pipe to the desired outside diameter.

In a later part of this paper, the topic of possible reductions will be further discussed.

Figure 4 — Section through coil box pinch rolls and leveler. The uncoiler should eliminate manual labor on heavy skelp and yet should be fast for light skelp.



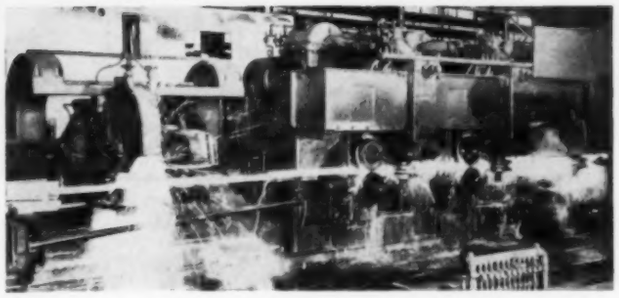
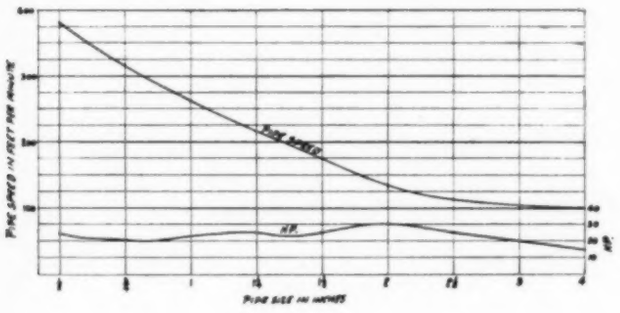


Figure 5 — The older forming and welding mills were usually operated by one drive motor with reduction gearing.

Figure 6 — The power requirements for a 6-stand forming and welding mill with a single motor drive is given by this graph.



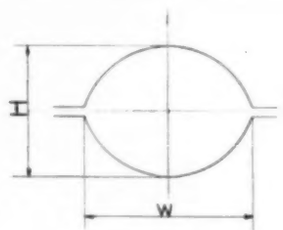
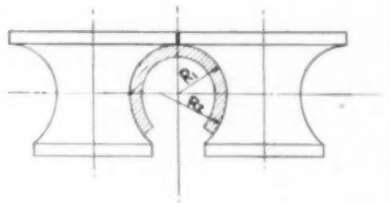
Additional units in a typical mill are as follows:

15. Flying hot saw—used for cutting pipe in desired lengths varying between 18 and 50 feet.
16. Conveyor No. 1.
17. Cooling rack No. 1—used for cooling pipe to desired descaling temperature.
18. Conveyor No. 2—used for feeding pipe into descaler.
19. Descaler or sizing mill—used for descaling and reduction of pipe to final hot size. A three-stand sizing mill is mostly used with a total reduction of approximately 5 per cent.
20. Conveyor No. 3.
21. Final cooling bed No. 2—If the pipe straighteners are connected to the hot mill, it is necessary to spray pipe here with cold water in order to bring pipe temperature down to approximately 150 F.
22. Straightener inlet tables.
23. Straightener.
24. Straightener outlet table.
25. Inspection skids.
26. Automatic facing machine.
27. Automatic pipe tester.

For further finishing operation the pipe from here is handled by crane to the pickling and galvanizing plant, automatic threading machines, coupling, screwing on machines, oiling machine and bundling table as shown in plant layout, Figure No. 1.

Due to the limited time, it is not possible to go into detailed description of the galvanizing and finishing

Figure 7 — This chart gives a typical method for designing the forming, welding and reducing passes.

A WELDING AND REDUCING PASSES	B SKELP DIMENSIONS	C FORMING PASS
		
W = TOTAL WIDTH OF GROOVE H = TOTAL HEIGHT OF GROOVE Dm = AVERAGE O.D. OF PIPE C = OVALITY = $\frac{W}{H}$ R = REDUCTION OF O.D. IN %	A = SKELP WIDTH t = SKELP THICKNESS = WALL THICKNESS OF FINISHED PIPE Dm = AVERAGE O.D. OF WELDING GROOVE = $\frac{W+2t}{\pi}$	R_1 = GROOVE TOP RADIUS R_2 = GROOVE BOTTOM RADIUS W = WIDTH OF SKELP
$\frac{W+t}{\pi} = Dm$ $H = 2Dm - W$ $W = \frac{\pi Dm}{1+\frac{1}{C}}$ $C = 1 + \frac{R}{100}$ * $**R = \left(\frac{Dm_1 - Dm_2}{Dm_1}\right) \times 100$	$A = (Dm - \frac{t}{2}) \times 3.14$	$R_1 = \frac{W}{5}$ $R_2 = 1.35\ R_1$
* THE INCREASE OF OVALITY PROVIDED BY THE INCREASE OF I HAS BEEN FOUND SATISFACTORY TO PREVENT OVERFILL OF PASS AND ROLL MARKS. THE OVALITY CAN BE VARIED TO SUIT THE PARTICULAR CONDITION. ** REDUCTION FROM OVAL TO ROUND FINISHING PASS SHOULD BE APPROXIMATELY ONE HALF OF THE REDUCTION FROM OVAL TO OVAL PASS.		

NOTE:
START CALCULATIONS OF PASS WITH FINISHING PASS, DETERMINE AVERAGE O.D. OF ALL PASSES, SKELP WIDTH AND DIMENSIONS FOR FORMING GROOVE.

ROLL R.P.M. FOR FORMING AND WELDING MILL BASED ON DELIVERY SPEED OF 100 R.P.M.

PIPE SIZE	PIPE O.D. COLD	STAND #	O.D. REDUCTION PER STAND %	ROLL DATA: METHOD O.DIA. INCH	ROLL DATA: AVERAGE MEAN DIA. INCH Dm	ROLL DATA: DIAMETER-PITCH RATIO D/E	ROLL DATA: DIA. ROLL "A" INCH	ROLL DATA: FACE "F"	ROLL DATA: DIA. CUTTER "D" INCH	ROLL DATA: GROOVE HGT. "E" INCH	ROLL DATA: DEPTH OF GROOVE "e" INCH	SPEED DATA: PITCH DIA "Pd" IN.	SPEED DATA: "Pd" X Dm	SPEED DATA: RELATIVE SPEED "V"	SPEED DATA: ROLL R.P.M. m	SPEED DATA: GEAR RATIO "R"	SPEED DATA: MOTOR R.P.M. "N"	SKELP DATA: STANDARD-PIPE	SKELP DATA: EXTRA-HEAVY-PIPE
½"		1					10.250	5							123	10.3	178		
		2		1.391	1.283	1.07	10.250	5	1.452	1.357	.6735	9.346	11.990	1	244	7.27	177.2		
		3	6	1.308	1.199	1.07	10.250	5	1.364	1.276	.633	9.400	11.270	1.064	26.0	7.27	189.0		
		4	6	1.229	1.120	1.07	10.250	5	1.282	1.198	.594	9.451	10.585	1.133	27.7	7.27	201.0		
		5	6	1.155	1.046	1.07	10.250	5	1.205	1.126	.558	9.500	9.937	1.207	28.5	6.42	189.0		
		6	6	1.086	.977	1.07	10.250	5	1.133	1.059	.5245	9.544	9.324	1.286	31.4	6.42	201.5		
		7	6	1.020	.911	1.07	10.250	5	1.064	.995	.4925	9.587	8.733	1.373	33.5	6.42	214.5		
		8	6	.959	.850	1.07	10.250	5	1.001	.935	.4625	9.627	8.182	1.465	36.8	5.72	210.5		
		9	6	.902	.793	1.07	10.250	5	.945	.875	.4325	9.664	7.635	1.565	38.2	5.72	218.5		
		10	3	.875	.766	1.07	10.250	5	.875	.875	.4325	9.667	7.404	1.619	39.5	5.72	225.5		
		11	3.16	.847	.738	1.07	14.000	5	.887	.822	.405	13.459	9.926	1					
		12	3	.822	.713	1.07	14.000	5	.822	.822	.406	13.453	9.591	1.035					
		13	0	.822	.713	1.07	14.000	5	.822	.822	.406	13.453	9.591	1.035					
¾"		1					10.250	5							18	10.3	185		
		2		1.749	1.636	1.07	10.250	5	1.825	1.705	.848	9.113	14.905	1	25.2	7.27	183		
		3	6	1.644	1.531	1.07	10.250	5	1.715	1.603	.797	9.182	14.057	1.061	26.8	7.27	194.5		
		4	6	1.545	1.432	1.07	10.250	5	1.612	1.506	.748	9.240	13.240	1.126	28.4	7.27	206		
		5	6	1.452	1.339	1.07	10.250	5	1.515	1.416	.703	9.306	12.466	1.197	30.2	6.42	194		
		6	6	1.365	1.252	1.07	10.250	5	1.424	1.331	.661	9.363	11.722	1.272	32.1	6.42	206		
		7	6	1.283	1.170	1.07	10.250	5	1.338	1.251	.621	9.416	11.016	1.353	34.2	6.42	219.5		
		8	6	1.206	1.093	1.07	10.250	5	1.258	1.176	.583	9.466	10.346	1.441	36.4	5.72	208		
		9	6	1.134	1.021	1.07	10.250	5	1.188	1.100	.545	9.513	9.712	1.535	38.8	5.72	222		
		10	3	1.100	.987	1.07	10.250	5	1.100	1.100	.545	9.518	9.374	1.687	40.1	5.72	229		
		11	3	1.067	.954	1.07	14.000	5	1.116	1.037	.513	13.306	12.697	1					
		12	2.82	1.037	.924	1.07	14.000	5	1.037	1.037	.514	13.308	12.296	1.033					
		13	0.00	1.037	.924	1.07	14.000	5	1.037	1.037	.514	13.308	12.296	1.033					
1"		1					10.250	5							18.5	10.3	190		
		2		2.178	2.045	1.07	10.250	5	2.272	2.124	1.057	8.834	18.057	1	26.0	7.27	189		
		3	6	2.047	1.914	1.07	10.250	5	2.135	1.996	.993	8.920	17.072	1.06	27.6	7.27	200.5		
		4	6	1.924	1.791	1.07	10.250	5	2.007	1.876	.933	9.000	16.119	1.12	29.2	7.27	212		
		5	6	1.809	1.676	1.07	10.250	5	1.887	1.764	.877	9.074	15.208	1.18	30.7	6.42	197		
		6	6	1.700	1.567	1.07	10.250	5	1.773	1.657	.824	9.145	14.330	1.26	32.8	6.42	210.5		
		7	6	1.598	1.465	1.07	10.250	5	1.667	1.558	.774	9.212	13.495	1.34	34.9	6.42	224		
		8	6	1.503	1.370	1.07	10.250	5	1.568	1.465	.728	9.275	12.704	1.42	37.0	5.72	212		
		9	6	1.412	1.279	1.07	10.250	5	1.481	1.370	.680	9.332	11.935	1.51	39.3	5.72	224		
		10	3	1.370	1.237	1.07	10.250	5	1.370	1.370	.680	9.338	11.551	1.57	40.9	5.72	234		
		11	3	1.329	1.196	1.07	14.000	5	1.386	1.296	.643	13.137	15.711	1					
		12	1.42	1.310	1.177	1.07	14.000	5	1.310	1.310	.650	13.128	15.951	1.083					
		13	0	1.310	1.177	1.07	14.000	5	1.310	1.310	.650	13.128	15.951	1.083					
1¼"		1					10.250	5							19.7	10.3	203		
		2		2.750	2.610	1.07	10.250	5	2.869	2.681	1.335	8.463	22.088	1	27.5	7.27	200		
		3	6	2.585	2.445	1.07	10.250	5	2.697	2.520	1.255	8.570	20.953	1.054	29.0	7.27	211		
		4	6	2.430	2.290	1.07	10.250	5	2.535	2.369	1.179	8.671	19.856	1.112	30.6	7.27	222		
		5	6	2.284	2.144	1.07	10.250	5	2.383	2.227	1.108	8.766	18.794	1.175	32.3	6.42	207.5		
		6	6	2.147	2.007	1.07	10.250	5	2.240	2.093	1.041	8.855	17.771	1.247	34.3	6.42	220		
		7	6	2.018	1.878	1.07	10.250	5	2.105	1.967	.978	8.939	16.787	1.316	36.2	6.42	232		
		8	6	1.897	1.757	1.07	10.250	5	1.979	1.849	.919	9.017	15.842	1.395	38.4	5.72	220		
		9	6	1.784	1.644	1.07	10.250	5	1.870	1.730	.860	9.091	14.935	1.478	40.6	5.72	232		
		10	3	1.730	1.590	1.07	10.250	5	1.730	1.730	.860	9.098	14.465	1.527	42.0	5.72	240		
		11	3	1.678	1.538	1.07	14.000	5	1.751	1.636	.813	12.911	17.867	1					
		12	1.55	1.652	1.512	1.07	14.000	5	1.652	1.652	.821	12.900	18.504	1.018					
		13	0	1.652	1.512	1.07	14.000	5	1.652	1.652	.821	12.900	18.504	1.018					
1½"		1				1.06	8.250	5¼							21.6	10.3	222		
		2		2.896	2.751	1.06	10.250	5	3.004	2.834	1.442	8.363	23.009	1	30.3	7.27	220		
		3	5	2.752	2.607	1.06	10.250	5	2.855	2.693	1.341	8.456	22.044	1.044	31.7	7.27	230		
		4	5	2.614	2.469	1.06	10.250	5	2.711	2.558	1.274	8.546	21.100	1.090	33.3	7.27	242		
		5	5	2.483	2.338	1.06	10.250	5	2.576	2.430	1.210	8.632	20.181	1.140	34.6	6.42	222		
		6	5	2.359	2.214	1.06	10.250	5	2.447	2.308	1.149	8.713	19.290	1.195	36.2	6.42	232		
		7	5	2.241	2.096	1.06	10.250	5	2.324	2.193	1.091	8.789	18.426	1.252	38.0	6.42	244		
		8	5	2.129	1.984	1.06	10.250	5	2.208	2.083	1.036	8.863	17.584	1.312	39.8	5.72	226		
		9	5	2.023	1.878	1.06	10.250	5	2.105	1.972	.981	8.932	16.774	1.375	41.6	5.72	238		
		10	2.50	1.972	1.827	1.06	10.250	5	1.972	1.972	.981	8.937	16.327	1.410	42.7	5.72	244		
		11	2.50	1.922	1.778	1.06	14.000	5	1.972	1.879	.934	12.749	22.667	1					
		12	1.60	1.892	1.747	1.06	14.000	5	1.892	1.892	.941	12.746	22.256	1.018					
		13	0	1.892	1.747	1.06	14.000	5	1.892	1.892	.941	12.746	22.256	1.018					
2"		1					10.250	6¾							24.5	10.3	252		
		2		3.336	3.182	1.05	10.250	5½	3.440	3.276	1.633	8.066	25.671	1	34.3	7.27	249		
		3	4	3.203	3.049	1.05	10.250	5½	3.303	3.143	1.568	8.155	24.871	1.032	35.9	7.27	257		
		4	4	3.075	2.921	1.05	10.250	5½	3.171	3.020	1.505	8.237	24.066	1.067	36.5	7.27	265		
		5	4	2.952	2.798	1.05	10.250	5½	3.044	2.897	1.444	8.318	23.273	1.103	37.8	6.42	241		
		6	4	2.834	2.680	1.05	10.250	5½	2.922	2.783	1.386	8.395	22.498	1.141	39.1	6.42	251		
		7	4	2.721	2.567	1.05	10.250	5½	2.806	2.672	1.331	8.469	21.739	1.181	40.5	6.42	260		
		8	4	2.612	2.458	1.05	10.250	5½	2.693	2.565	1.277	8.540	20.991	1.223	41.9	5.72	238.5		
		9	4	2.507	2.353	1.05	10.250	5½	2.585	2.457	1.223	8.609	20.256	1.267	43.4	5.72	248		
		10	2	2.457	2.303	1.05	10.250	5½	2.457	2.457	1.224	8.614	19.838	1.294	44.4	5.72	254		
		11	2	2.407	2.263	1.05	14.000	5	2.481	2.363	1.177	12.426	27.995	1					
		12	1.24	2.378	2.224	1.05	14.000	5	2.378	2.378	1.184	12.416	27.619	1.014					
		13	0	2.378	2.224	1.05	14.000	5	2.378	2.378	1.184	12.416	27.619	1.014					
2½"		1					10.250	6¾							25.9	10.3	266		
		2		4.011	3.848	1.05	10.250	5½	4.136	3.939	1.969	7.624	29.332	1	36.2	7.27	263		
		3	4	3.851	3.688	1.05	10.250	5½	3.971	3.782	1.886	7.787	28.771	1.030	37.3	7.27	271		
		4	4	3.697	3.494	1.05	10.250	5½	3.812	3.631	1.810	7.836	27.538	1.061	38.4	7.27	279		
		5	4	3.549	3.346	1.05	10.250	5½	3.659	3.485	1.737	7.927	26.523	1.095	39.6	6.42	254		
		6	4	3.401	3.198	1.05	10.250	5½	3.507	3.346	1.665	8.024	25.660	1.131	40.9	6.42	262.5		
		7	4	3.271	3.068	1.05	10.250	6¾	3.373	3.212	1.601	8.109	24.878	1.167	42.2	6.42	271		
		8	4	3.140	2.937	1.05	10.250	6¾	3.238	3.083	1.536	8.185	24.065	1.206	43.6	5.72	249.5		
		9	4	3.014	2.811	1.05	10.250	6¾	3.114	2.954	1.472	8.277	23.266	1.248	45.1	5.72	258		
		10	2	2.954	2.751	1.05	10.250	5½	2.854	2.954	1.472	8.283	22.786	1.274	46.1	5.72	264		
		11	1	2.924	2.721	1.05	14.000	5	3.015	2.871	1.431	12.498	32.981	1					
		12	1.2	2.890	2.687	1.05	14.000	5	2.890	2.894	1.440	12.476	32.457	1.014					
		13	0	2.890	2.687	1.05	14.000	5	2.890	2.890	1.440	12.476	32.457	1.014					

ROLL R.P.M. FOR FORMING AND WELDING MILL BASED ON DELIVERY SPEED OF 100 R.P.M.

PIPE SIZE	PIPE O.D. COLD	STAND #	O.D. REDUCT. PER STAND %	METRIC O.DIA. INCH	METRIC MEAN DIA. INCH Dm	DIA. CUTTER GROOVE HGT. D/E	ROLL DATA: DIA. ROLL "A" INCH	FACE "F"	DIA. CUTTER "D" INCH	GROOVE HGT. "E" INCH	DEPTH OF GROOVE "e" INCH	SPEED DATA: PITCH DIA "Pd" IN.	"Pd" X Dm	RELATIVE SPEED "V"	ROLL R.P.M. m	GEAR RATIO "R"	MOTOR R.P.M. "N"	SKELP DATA: STANDARD PIPE	EXTRA HEAVY PIPE
1¼"		1																	
		2																	
		3																	
		4																	
		5																	
		6																	
		7																	
		8																	
		9																	
		10																	
		11																	
		12																	
		13																	
3"		1					10.250	7 7/8							284	10.3	302		
		2		4.502	4.286	1.05	10.250	5½	4.642	4.421	2.205	7.303	31.30	1	41.1	7.27	298	216"	300"
		3	3	4.367	4.151	1.05	10.250	5½	4.503	4.289	2.139	7.391	30.68	1.02	41.9	7.27	304		
		4	3	4.236	4.020	1.05	10.250	5½	4.368	4.160	2.075	7.477	30.06	1.04	42.7	7.27	310		
		5	3	4.109	3.893	1.05	10.250	5½	4.237	4.035	2.012	7.560	29.43	1.064	43.7	6.42	280.5		
		6	3	3.986	3.770	1.05	10.250	5½	4.111	3.914	1.952	7.641	28.81	1.087	44.6	6.42	286		
		7	3	3.866	3.650	1.05	10.250	5½	3.986	3.797	1.893	7.719	28.17	1.111	45.6	6.42	292.5		
		8	3	3.750	3.534	1.05	10.250	5½	3.867	3.685	1.836	7.795	27.55	1.136	46.6	5.72	266		
		9	3	3.638	3.422	1.05	10.250	5½	3.751	3.573	1.781	7.868	26.92	1.163	47.8	5.72	275		
		10	1.50	3.583	3.367	1.05	10.250	5½	3.583	3.583	1.787	7.864	26.48	1.182	48.6	5.72	278		
		11	1	3.547	3.331	1.05	14.000	5	3.658	3.484	1.737	11.678	38.89	1					
		12	0.55	3.529	3.313	1.05	14.000	5	3.529	3.524	1.757	11.652	38.69	1.008					
		13	0	3.529	3.313	1.05	14.000	5	3.529	3.524	1.759	11.652	38.59	1.009					
3½"		1					10.250	7 7/8							32.6	10.3	336		
		2		4.747	4.521	1.04	10.250	6¾	4.872	4.688	2.339	7.125	32.21	1	45.7	7.27	332	226"	318"
		3	2	4.652	4.426	1.04	10.250	6¾	4.776	4.594	2.292	7.188	31.82	1.013	46.3	7.27	336		
		4	2	4.557	4.335	1.04	10.250	6¾	4.681	4.502	2.246	7.249	31.41	1.026	46.8	7.27	340		
		5	2	4.468	4.242	1.04	10.250	6¾	4.588	4.412	2.201	7.309	31.00	1.039	47.4	6.42	304		
		6	2	4.379	4.153	1.04	10.250	6¾	4.497	4.324	2.157	7.368	30.60	1.053	48.2	6.42	309		
		7	2	4.291	4.065	1.04	10.250	6¾	4.408	4.238	2.113	7.426	30.19	1.067	48.7	6.42	313		
		8	2	4.205	3.979	1.04	10.250	6¾	4.319	4.153	2.071	7.482	29.77	1.082	49.5	5.72	283		
		9	2	4.121	3.895	1.04	10.250	6¾	4.232	4.070	2.030	7.537	29.36	1.097	50.1	5.72	286		
		10	1	4.080	3.854	1.04	10.250	6¾	4.080	4.080	2.035	7.533	29.03	1.110	50.7	5.72	290		
		11	1	4.039	3.813	1.04	14.000	6¼	4.149	3.990	1.990	11.329	43.236	1.00					
		12	0.95	4.025	3.799	1.04	14.000	6¼	4.025	4.025	2.008	11.318	42.986	1.006					
		13	0	4.025	3.799	1.04	14.000	6¼	4.025	4.025	2.008	11.318	42.986	1.006					
4"		1					10.250	7 7/8							36.1	10.3	372		
		2		4.921	4.684	1.04	10.250	6¾	5.053	4.860	2.425	7.010	32.83	1	50.7	7.27	368.6	237"	337"
		3	2	4.822	4.585	1.04	10.250	6¾	4.953	4.762	2.376	7.076	32.44	1.014	51.4	7.27	373.7		
		4	2	4.726	4.489	1.04	10.250	6¾	4.859	4.667	2.328	7.139	32.85	1.026	52.0	7.27	378		
		5	2	4.631	4.394	1.04	10.250	6¾	4.757	4.573	2.281	7.202	31.65	1.037	52.6	6.42	337.7		
		6	1	4.585	4.348	1.04	10.250	6¾	4.585	4.585	2.288	7.197	31.29	1.049	53.2	6.42	341.5		
		7					—	—	—						—	6.42	—		
		8					10.250	6¾	4.650	4.650	2.320				68.2	5.72	389.1	15.370"	15.300"
		9					—	—	—	—	—				—	5.72	—		
		10					10.250	6¾	4.650	4.650	2.320				68.2	5.72	389.1		
		11	1	4.539	4.342	1.04	14.000	6¼	4.643	4.494	2.237	11.044	47.37	1					
		12	0.21	4.530	4.293	1.04	14.000	6¼	4.530	4.530	2.260	10.978	47.14	1.005					
		13	0	4.530	4.293	1.04	14.000	6¼	4.530	4.530	2.260	10.978	47.14	1.005					

Figure 8 — The roll dimensions and skelp data for a 10-stand forming and welding mill and a 3-stand sizing mill with individual motor drives are given in this chart.

operations. This paper will primarily discuss the hot mill installation.

In order to have an efficient mill, the arrangement and selection of the finishing floor, pickling and galvanizing equipment is of the utmost importance. Before concluding the general description of the hot mill, the uncoiling, forming and welding mill and furnace threading will be briefly discussed.

The weight of coils or length of skelp in a coil is a major factor and must be given thorough consideration. A loop must be formed of sufficient length so that time is available for the end-welder to position ends of two coils in welder, make weld, and flash trim and this requires approximately one minute. This time varies slightly depending upon the size of skelp.

In the design of the uncoiler, two important requirements must be met.

1. The tail end of leaving coil and the front end of new coil must follow each other as close as possible.
2. The coil ends of skelp for extra heavy and double extra heavy pipe are to be entered into roller leveller with the minimum amount of manual labor.

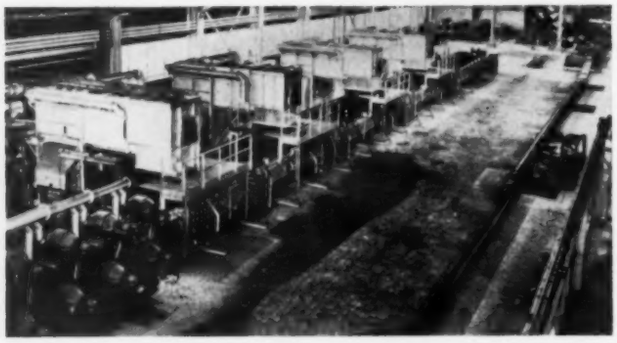
Figure 3 illustrates a mandrel type uncoiler very suitable for skelp sizes for 1¼ to 4 in. pipe.

The handling of coils and starting into the leveller is accomplished without any manual effort. While one coil is being uncoiled a second coil is placed on the transfer carriage, ready to be pushed on lower mandrel. The upper roll is driven from roller leveller. The lower coil carrying mandrel is an idler attached to an oil hydraulic lifting device. The uncoiling is started by squeezing the coil between lower mandrel and upper driven roll.

For narrow coils, small pipe size where greatest speed is required, this uncoiler is not suitable on account of the time required for transferring a coil from the coil storage carriage to the lower mandrel. For a mill having a capacity of ½ to 4 in. pipe, an uncoiler is required which will eliminate the manual labor on the heavy size

Figure 9 — The flash welder is used for butt welding the coils together.

Figure 10 — The skelp heating furnace heats the skelp to a temperature of 2450 F.



skelp and at the same time is fast for the small pipe coil size. Figure 4 shows an uncoiler fulfilling both requirements.

For the heavy skelp size a pusher is used to uncoil an end of sufficient length to be fed into roller leveller. Ahead of the uncoiling station, two motor driven carrier rolls position the uncoiled end, so that pinch rolls can grip this end and feed it into the roller leveller. The coil is then transferred from carrier rolls to uncoiling stations by an air operated kickout.

With this arrangement it is possible, particularly with the lighter skelp size, to have the tail end of one coil and front end of the new coil follow each other practically without a gap.

Figure 5 shows a photograph of a forming and welding mill. As mentioned before, the first mills were built with six stands driven through suitable gearing by one 40 hp motor. In addition, through a clutch arrangement the saw was driven from the same motor. The mills were designed for a maximum speed of 400 fpm.

Figure 6 shows a chart giving the actual power requirement for a 6-stand forming and welding mill for various pipe sizes and speeds based on a reduction per stand in diameter of approximately 3 per cent.

Later more modern mills were designed with individual motor drives for each stand. The individual motor driven mill offers the following advantages:

1. Greater flexibility, that is, for each pipe size the most desired reduction per pass can be obtained and still all roll diameters can be the same in the entire mill.
2. If it is found that the wall thickness is too heavy or too light, in a very short time the speed of the last few stands can be adjusted until the desired wall has been established.
3. Lower roll cost per ton of pipe produced, since all roll stands can use the maximum diameter roll and therefore, more roll dressings can be obtained.

As a rule each mill stand is powered by a 25 hp motor. All motors including the driving motor for flying saw and pinch roll No. 2 are connected to a common motor-generator set. It has been found that the synchronization of mill is not critical at all.

The operator uses the various ammeters provided for each motor as a guide for adjusting the motor speeds. Vernier rheostats are provided for each motor. A common rheostat is provided to adjust the complete mill speed, including saw and pinch roll No. 2 to suit furnace and welding temperature of skelp.

Figure 11 — Controls are conveniently arranged on the main operator's bench board.

Figure 12 — The sizing mill is used to reduce the pipe to the final hot size and to descale the pipe.

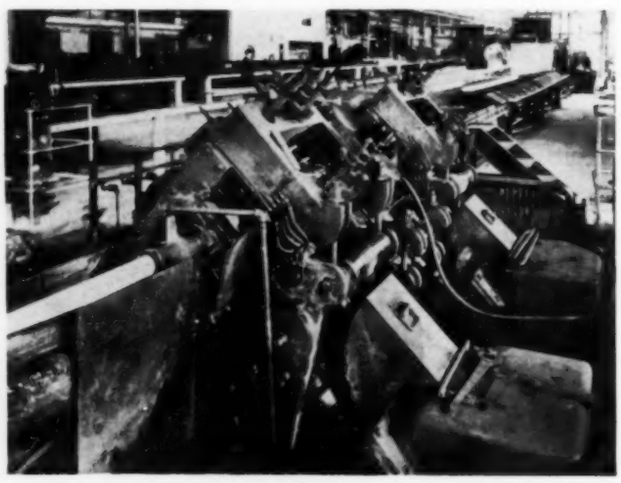


Figure 7 shows method of pass calculations for forming, welding, and reducing passes, and calculation of skelp width. Figure 8 shows a typical roll chart for a ten-stand forming and welding mill, and three stand sizing mill with individual motor drives.

The furnace threading-in the first mill installations was done with a long pipe needle approximately 150 ft long, depending on the length of furnace. This needle was welded to the skelp to be pulled through the furnace. By manual power, this needle had to be pushed through the furnace. After the needle had reached the forming and welding mill, a cable was attached and by means of a winch, the skelp was pulled through the furnace into the forming rolls and gradually into the other mill passes. The needle was then cut off by the flying saw and would be used over again. Various sized needles had to be used for the various pipe sizes.

A furnace skelp threading machine has been developed which eliminates the needle threading, and the manual labor connected with it, and also the number of needles which had to be handled and stored. This threading machine consists of a pair of pinch rolls, one

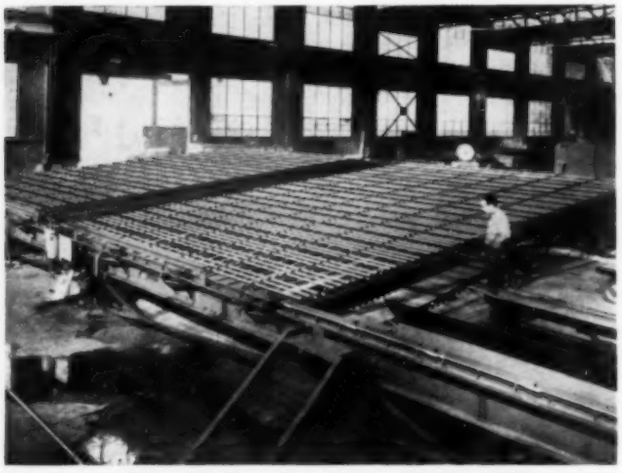


Figure 13 — Pipe manufacture requires extensive cooling beds.

with concave and one with convex contour. The skelp fed through the rolls is being formed into a dished shape which has sufficient stiffness to be pushed through the furnace.

After the skelp reaches the forming rolls, a tong, with an extension long enough to reach through the mill, grips the skelp and by means of a cable and winch the skelp is pulled into the forming rolls and following mill passes. After the skelp has reached the forming pass, the furnace threading machine rolls are opened. The skelp supporting skids are pulled out of the furnace during the threading operation, that is, the skelp is pushed over the furnace floor. After the skelp is pulled into the mill the furnace skids are pushed back under the skelp.

Figures 9-13 show a few typical pictures of equipment used in the mill shown in Figure 1. Figure 9 shows the flash welder, Figure 10, the furnace, Figure 11, the main operator bench board, Figure 12, the sizing mill, and Figure 13, the cooling beds

The mandrel type uncoiler, welding horn and furnace threading machine are patented.

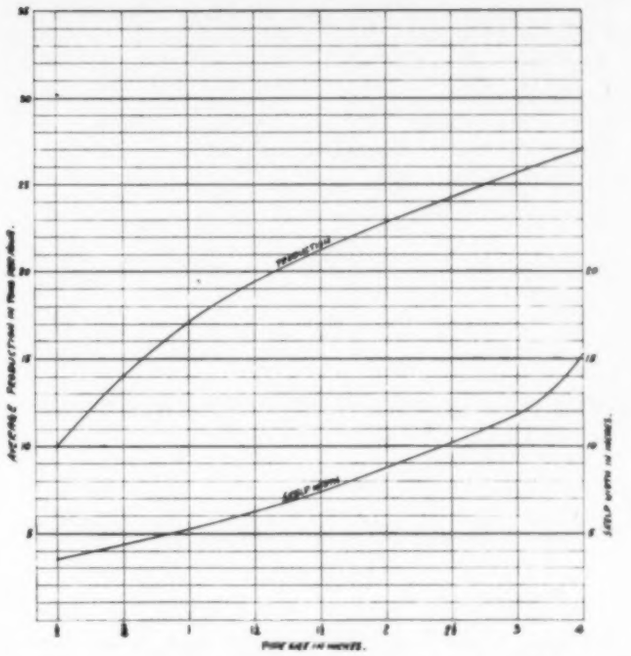
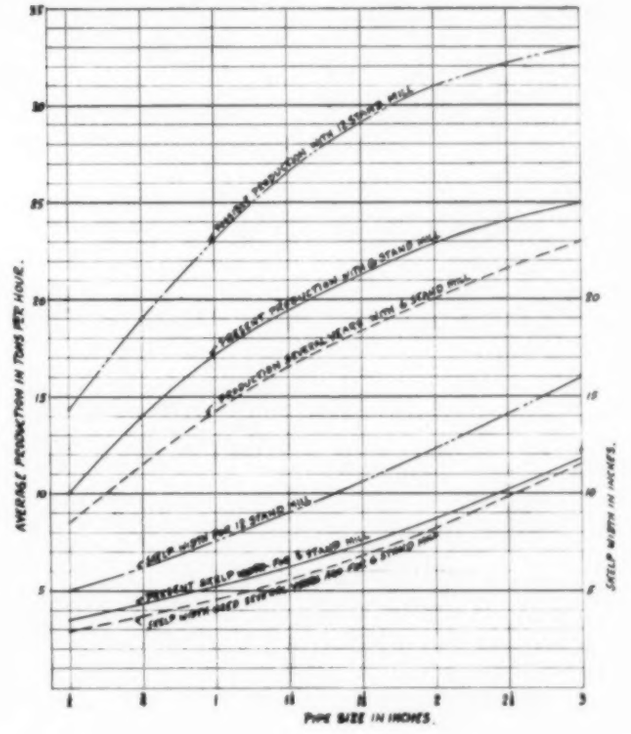


Figure 14 — The chart gives the average production for a 6-stand forming and welding mill, served by a skelp heating furnace which is 147 ft long.

A production chart of a mill as described is shown in Figure 14.

The yield obtained in above mills including finishing floor is approximately 94 per cent. The material used for pipe is mostly 0.05 to 0.08 per cent carbon steel, and pipe of 0.20 to 0.25 per cent carbon steel has also been made.

Figure 15 — This chart correlates production with skelp width for two pipe mills each served by a skelp heating furnace 147 ft long.



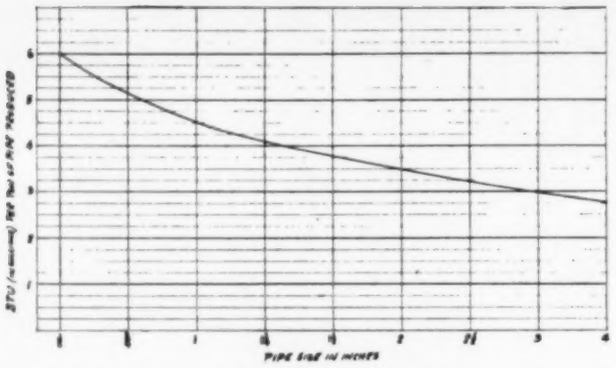


Figure 16 — Fuel consumptions required for heating skelp for various pipe sizes are given by this chart.

MORE EFFICIENT CONTINUOUS BUTT WELD PIPE MILLS

Production has been increased in existing mills by the use of wider skelp and by increasing heating capacity of furnace by adding burners in preheat zone and improved burner design.

The original forming and welding mills had a total of six stands, and reduction of outside diameter per pass after welding pass was approximately 3 per cent. Today one mill is in operation with a ten-stand forming and welding mill and reduction per pass up to 8 per cent for the smaller pipe sizes.

Several mills are now under construction with a twelve-stand forming and welding mill. The chart of Figure 15 shows a comparison of skelp widths and production for six-stand forming and welding mills several years ago, and revised as of today. The same chart also shows the skelp width and production possibilities for twelve-stand forming and welding mills.

The use of wider skelp and greater reductions after welding pass offers the following advantages:

1. Higher production of pipe mill.
2. Higher furnace capacity in tons per hour. The furnace capacity increases with the cross-sectional area of skelp, greater furnace efficiency, i.e., less Btu per tons of skelp heated.
3. Higher production and lower cost per ton of skelp produced in skelp mill.
4. Heavier coils from skelp mill which result in fewer end welds of flash welder per ton of pipe. (It also increases time available for making end weld).
5. Better product, the increased reduction immediately after welding improves the weld.

On existing installations it is the practice to use skelp with a thickness equivalent to that of the final wall thickness of pipe.

Figure 16 shows approximate fuel consumption Btu per ton of skelp heated for various pipe sizes. These figures are based on skelp widths for six-stand forming and welding mill. No Btu figures are available at present for skelp width based on ten-stand forming and welding mill. However, based on information obtained, the fuel consumption will be approximately 20 per cent less, in particular on the smaller pipe sizes where the width of skelp increase was the greatest.

The pass speeds in the mill are calculated to prevent any upsetting or increase in wall. The stretch reducing process used by some manufacturers of seamless tubes would have an ideal application in a continuous mill, that is, there would be no problem of heavy ends. By utilizing this process the final wall thickness produced could be 10 to 20 per cent lighter than the rolled skelp thickness. The power requirements on the mill would of course, becomes considerably greater than as at present. Stretch reducing probably would be of greatest advantage to produce pipe with light wall and possible lighter walls than are being produced at present.

It is to be assumed that the maximum reduction possible in a mill of this type would depend upon a ratio of skelp width over wall thickness which can be formed and welded without collapsing. With increased skelp

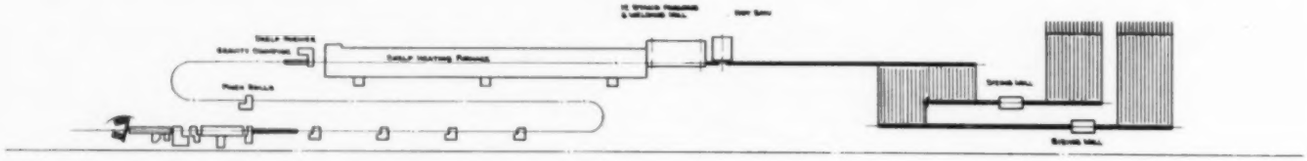
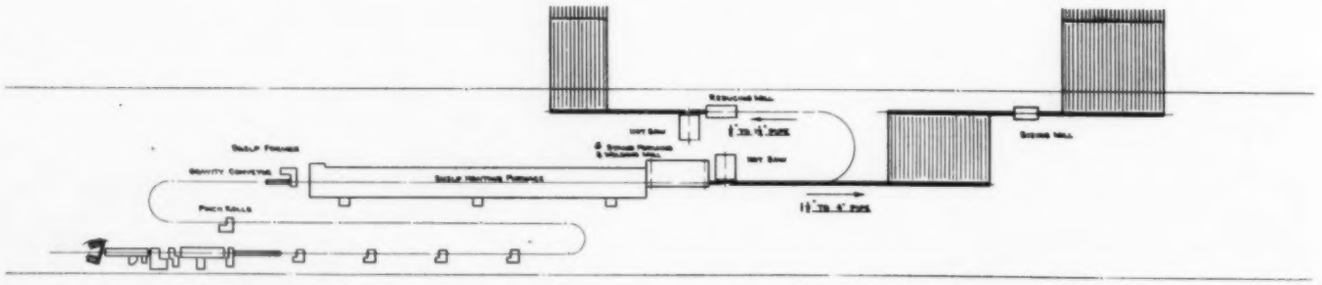


Figure 17 — The continuous butt weld pipe mill shown will have a speed of 1000 fpm.

Figure 18 — This mill has a larger range than the one shown in Figure 17.



thickness, therefore, greater reduction would be possible. In the present mills, the maximum ratio $\frac{W}{T}$ successfully formed and welded has been about 100:1. The maximum speed of present installations is around 500 fpm. This speed is governed by the speed limitation of present flying saws. With a higher speed saw, the maximum speed of some existing installations could be increased possibly 25 per cent.

At present there are under construction installations with a maximum speed of 1000 fpm. These mills will have forming and welding mills with twelve-stands.

A new type saw is under construction for 1000 fpm. The saw is being built for a size range from ½ to 1½ in. and lengths of cut from 18 to 54 ft. The cutting tolerances expected are to be the same or better than on existing saws. These higher speed mills will be equipped with improved conveyors, kickoffs, and cooling beds. Figure 17 shows a layout of a mill with a maximum speed of 1000 fpm and size range of ½ to 1½ in. Figure 18 shows a layout of a larger range mill with size range ½ to 4 in. With the latter layout, the reducing mill for small pipe sizes can be in operation while the sizing mill for larger pipe sizes is set up.

Wherever the production requirements justify two installations, the mill capacities are divided into a small mill with ½ to 1½ in. capacity, and a large mill with 1¼ to 4 in. capacity.

DISCUSSION

PRESENTED BY

M. G. MORGAN, Assistant Superintendent, Butt Weld Tube Mills, Campbell Works, Youngstown Sheet and Tube Co., Campbell, Ohio

WILLIAM RODDER, Vice President in Charge of Engineering, The Aetna-Standard Engineering Co., Youngstown, Ohio

H. R. BEACHLER, Works Manager, Spang-Chalfant Division of the National Supply Co., Etna, Pittsburgh, Pa.

LOUIS MOSES, Superintendent, Rail Mill and Roll Department, Bethlehem Steel Co., Sparrows Point, Md.

R. E. BUCKHOLDT, Development and Research Engineer, Salem Engineering Co., Salem, Ohio

JOSEPH WADLECK, Development Engineer, The Aetna-Standard Engineering Co., Youngstown, Ohio

M. G. Morgan: There are two questions I would like to ask Mr. Rodder. He stated, first, that there was an ideal reduction in the welding pass of 4 to 6 per cent. I would like to ask Mr. Rodder how this reduction is figured.

William Rodder: I mentioned that good welding practice shows a reduction of 4 to 6 per cent in the welding pass. This reduction is based on the skelp area entering the welding stand and the pipe area leaving the welding stand. A method of calculating passes and skelp width is shown in the charts of Figures 8 and 9. When calculating the passes and skelp width for a mill, the starting point is the finishing groove diameter which is determined by the pipe size. Reductions per stand based on good practice are assumed. With this information the average pipe diameters for each pass are determined. The average outside diameter of pipe in welding pass determines the skelp widths. Widths of skelp = $\frac{(D_m - t)}{4} \times 3.14$. D_m = average outside diameter welding groove. T = wall thickness.

Years ago instead of deducting ¼ wall from D_m the practice was to deduct ½ wall. This, of course, would result in a narrower skelp for a given welding groove size. Actual practice proved that a slightly wider skelp produced better welds.

M. G. Morgan: You state that years ago ½ wall thickness was deducted in your formula from the average outside diameter, at the present time you deduct ¼ of the wall thickness. Is there a difference in the appearance of the pipe?

William Rodder: There is no difference in the appearance of the pipe. The slight increase in widths of skelp does not produce an over-fill or caves in the pipe. It is very important that an area reduction is made in the welding pass. If there is not sufficient material to make such a reduction then no good welds can be produced. On the other hand, if the reduction in area is too great there is danger of the pipe caving or indicating an overfill on the weld.

M. G. Morgan: You mentioned that oxygen has been applied experimentally between the forming and welding pass. Just how much of this has been done?

William Rodder: I understand good results have been obtained. I do not think it is used very often. The use of oxygen would give a higher edge temperature increase than the use of compressed air. Therefore, the skelp leaving the furnace can have a temperature slightly lower which permits a higher skelp speed through the furnace.

M. G. Morgan: You also mentioned that skelp with square and bevel edges have been used and that the skelp with the bevel edge is preferred. Is there a good reason for using the skelp with the bevel edge?

William Rodder: The mills all started out using the bevel edge. It was the assumed practice. In recent years some manufacturers have used skelp with square edges and found no difference in the product. However, when making double extra heavy wall pipe, a bevel edge is required.

M. G. Morgan: Would it make any difference in the edge temperature whether one uses square or bevel edge?

William Rodder: I would not be able to answer this question. It is possible that the square edge requires a slightly higher temperature.

M. G. Morgan: There is another question I would like to ask in regard to the mill drives. You mentioned about a single motor driven mill using a 40 hp motor and the mills with individual motor drives using 25 hp per stand. Is there any difference in the power consumption?

William Rodder: The original six-stand mills which were built with one 40 hp drive were designed for lighter reductions and lower speeds than is contemplated for the new mills with individual motor drives. When designing a mill with individual motor drives, it is to be

taken into consideration that the power required for the various stands is not the same, the stands toward delivery end of mill are considerably more heavily loaded than the stands at the entry end of mill. In order to have duplicate motors on the mill, the size of motor is determined by the stand requiring the most hp. The size of motor-generator set is based on the actual power required for driving the entire mill.

Answering your question in regard to power consumption, there should be no difference in kwhr used per ton of pipe produced whether the mill is driven by a single motor drive or individual motor drive.

M. G. Morgan: As I understand it, each motor has one individual rheostat and ammeter required for adjustment.

William Rodder: This is correct. The operator uses the vernier rheostat for the initial setup of mill. For operation one master rheostat controls the complete mill.

H. R. Beachler: What type of saw is used on a mill having a speed of 1000 fpm.

William Rodder: The saw under construction is of the rotating type running continuously. When a cut is to be made, the pipe is lifted into the saw blade. The action of this saw is similar to a rotating drum type shear except that instead of the upper knife, a saw is used, and the lower rotating drum lifts the pipe into the saw blade. This saw has a range from ½ to 1½ in. For larger pipe sizes I think it will be necessary to depress the saw blade through the pipe.

H. R. Beachler: In taking a greater reduction do you improve the weld? I wonder about this because in my mind there is just a little question whether that is actually what happens. I think that the instant you hit the crown of your welding pass your weld is made instantaneously right there. You know we are contemplating putting in a 10-stand mill at Etna and you are building the mill for us. This new mill we calculate will have reductions of 4½ to 5 per cent and we would like to go higher but run into difficulty on account of not being able to get the right skelp widths. Our supplier is not able to give us the wider skelp required for the greater reduction.

William Rodder: The data we obtained from operators who changed from a 3 per cent reduction per stand to 8 per cent showed definite improvements in the weld. The higher quality of weld is demonstrated by expansion tests and flattening tests on the pipe. I think you are quite right that the weld is made instantaneously in the welding pass. However, the increased work being done on the weld later on improves the grain structure in the weld.

Member: How long does it take to change rolls on a mill of that type?

William Rodder: On the 6-stand mill it takes 1½ to two hours to change the rolls. It naturally would take twice as long to change the rolls on a 12-stand mill unless you can put some extra men on the job.

Member: When you change sizes on the mill, how long does it take to thread that skelp through the furnace and through the forming mill?

William Rodder: On the average, I would say you are making pipe in about 10 minutes.

Louis Moses: A successfully accomplished butt welding operation includes the essentially solid weld at the outside diameter to insure an unmarred finished thread. Otherwise, a threaded joint could not be made tightly in its couplings. Beveled edge skelp is employed for this reason, with the action when the skelp is formed shown by the Figure 19.

Regarding determinations of skelp width, there does not appear to be any one formula applying to any and all pipe sizes, without allowance for both outside diameter and wall thicknesses. As practiced daily, the precise relationships between the various sizes will vary, yet the skelp used in each one gives a good product.

The cross-section of the pipe in the welding stand is oversize in comparison with the finished outside diameter. This is arranged to permit reduction in the succeeding stands, which forges the weld and confers metallurgical properties.

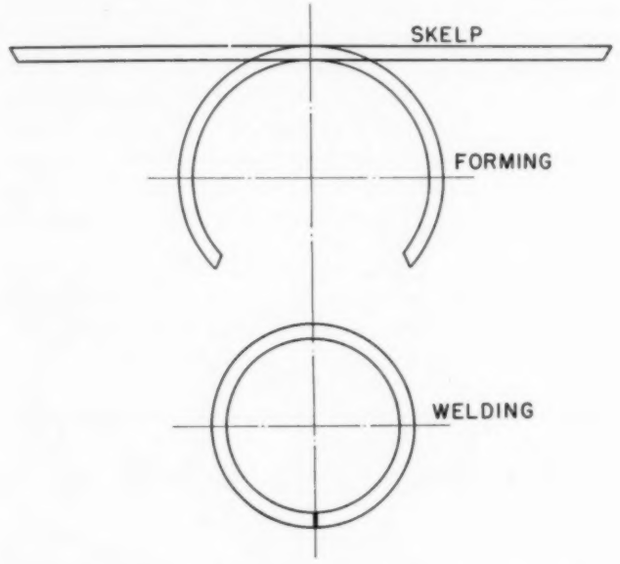


Figure 19 — Beveled edge skelp is used in order to insure the smooth surface on the outside of the pipe which is required for threading the pipe.

In all passes, the permissible physical amount of "hugging" action, without any slippage, against the walls of the roll grooves is a determining factor in the design. For instance, a ⅜ in. pipe is, proportionately, closer to that of a solid bar in its action through the train of rolls than is a 4 in. pipe.

Again, at one extreme for any given size or weight, insufficient stock in the welding rolls would not create enough pressure at the ends to make a weld. As compared to the exact correct dimension, any great overage of skelp width does not increase the pressure making a weld; in fact, the reverse is true because under such a condition the ends will either overlap or caving will occur. Within allowable tolerances of width, caving does not occur, but such excess width simply goes into elongation. Very little increase in wall thickness occurs, due to the high temperature of the material.

In other words the ruling factor, both in the welding rolls and in all later stands, is somewhat analogous to the properties of a column under the principle of the least radius of gyration. Pressures which are too great to be confined within the profile of a pass will merely

cave the wall. It will be found that any successful operation has passed through a phase of trial and error and also that from time to time these proportions are "touched-up" through experience with individual pipe sizes and weights.

I would like to ask Mr. Rodder if the wall thickness is actually being reduced from a thicker gage to finished pipe wall thickness in the ten and twelve-stand mills he describes?

William Rodder: No, not on present installations, however, I feel there is a great possibility doing just that to a great extent, of course it will require more power on the mill.

R. E. Buckholdt: With the new forming and welding mills handling wider skelp than previously used, greater efficiency can be realized in furnace operation. Wider skelp offers greater surface to receive heat. In some sizes the skelp width has been increased approximately 75 per cent. The skelp section area, however, is still small in comparison to the furnace section area.

With this condition present it was apparent that an improvement could be made in a burner to better concentrate the heat liberated from the flame directly on the skelp edges. This has been accomplished by opening or enlarging the combustion tile and obtaining faster mixing of the air and gas with a multijet gas outlet.

Flame stingers at skid pipe openings have been nearly eliminated.

With the furnace temperature averaging 2400 F—2000 F at the charging end and 2800 F at the discharge end, it is extremely important to maintain a uniform fuel-air ratio so that the highest possible flame temperature can be obtained. Incorrect ratio at these high temperatures not only wastes fuel but also creates a flame temperature lower than that which is required, thus reducing production. The preheated air therefore must be accurately metered and free from dilution in the form of foreign gases.

Additional improvements will be tried during the next year, and when this information is proven and available, it will be presented to you.

J. P. Wadleck: With reference to Mr. Rodder's very important statement relative to improved quality of weld with increased reduction rates and with increased overall reduction by raising the number of reducing stands from 4 to 8, or 10, I would like to make the following comments:

The formed circular cross-section skelp, pressure welded in the welding stand of the Fretz-Moon mill, from a metallurgical point of view, is in the same state as two pieces of steel forge-welded on the blacksmith shop's anvil or in a forging press.

I am sure we all know, or at least have heard of the objectionable properties of coarse grain steels and of the superior quality of fine grain steels with their greater ductility, elongation, impact, and fatigue strengths. The grain structure of the skelp before the welding stand, in consequence of being heated well above its grain coarsening temperature (of 1850/1900 F) is greatly coarsened. In order to bring this coarsened grain structure back to its preheated state we shall have to do the same thing that the blacksmith is doing, i.e., the piece will have to be hot-worked over a temperature range. The greater the amount of "working," which in tube making can best be expressed by its overall deformation that the tube will be subject to, the more reassured we can feel of its satisfactory grain size.

The most important aspect of tube making, however, is the strength of the pipe in the fusion zone. For good fusion the surfaces which come into contact must be free from oxide (scale). This oxide has to be removed either mechanically "by scraping" or by the application of some oxide melting or dissolving substance such as clean silica sand or borax, or we have to rely upon the squeezing action of the skelp faces which come into contact.

It appears to me that the greatest justification of the use of tapered edged skelp lies in its utilization for this oxide squeezing action, as with tapered edges the contact begins at the outside (maximum) radius of the shell which is on the top, and as the radial thickness of contact increases from the outer to the inner periphery of pipe, the scale is always squeezed out ahead of the approaching points of contact.

Assuming now an oxide free contact surface, to attain the cohesional bond which is the pre-requisite of sound fusion, it is essential that between the particles of engaging surfaces in relation of one particle to the other, a large amount of slip should take place. Obviously, this slip is greater with larger drafts (limited only by the danger point of wall buckling) than with lesser diametral reductions.

In conclusion, with a greater number of reducing stands and increased reduction rates per stand, both of which will result in greatly increased overall pipe elongation, the density of any initial imperfections or impurities in the fusion zone of the original contact length, the skelp length, will be reduced in proportion to the ratio of final pipe length to skelp length.

Make your plans to attend!

ANNUAL SPRING CONFERENCE

ASSOCIATION OF IRON AND STEEL ENGINEERS

LORD BALTIMORE HOTEL BALTIMORE, MARYLAND

MAY 2 and 3, 1949

A NEW 170-TON OPEN HEARTH

By IR. E. VOET

Superintendent Furnace Construction Department

Royal Dutch Blast Furnace and Steel Works

Ijmuiden, Holland

▲The decision to build a new furnace with a capacity twice that of the already existing furnace was taken in December, 1946. By the end of January, 1948, the first charge was tapped successfully. The design of the furnace is that of the furnace construction department of the Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V. (Royal Dutch Blast Furnace and Steel Works, Ijmuiden, Holland).

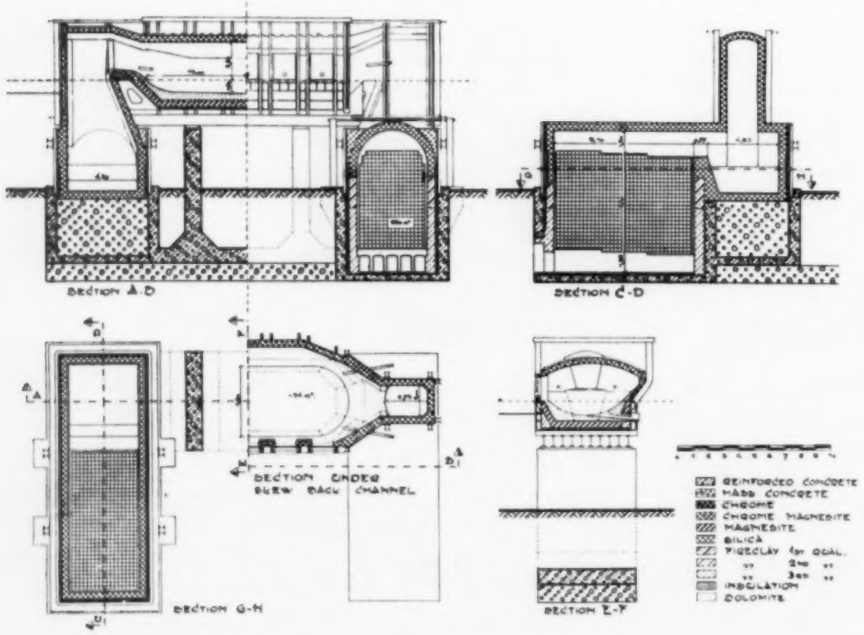
The conventional construction of oil-fired open hearth furnaces with one oil burner between two air uptakes at each end has been abandoned. Encouraging results with two burners at each end of the original gas-fired 80-ton venturi furnaces of the company led to the construction as shown in Figure 1 with one air uptake between two oil burners directed towards the center of the bath area.

Special attention is given to the cooling system. A minimum of cooled surface is installed in the hottest part of the furnace, i.e., the furnace laboratory. Only the doors, door frames and burners are cooled.

The principal dimensions are:

Length of bath	42 ft 8 in.
Width of bath	14 ft 9 in.
Depth of bath	2 ft 11 in.
Surface of bath	62,935 sq ft
Span of roof	19 ft 9 in.
Height, foreplate to skewback (frontwall)	5 ft 3 in.
Height, foreplate to roofcrown	8 ft 0 in.
Uptake area	58.0 sq ft
Width of slag pocket	14 ft 9 in.
Length of regenerator	29 ft 10 in.
Width of regenerator	14 ft 9 in.
Height of checkerwork	20 ft 8 in.
Total height of regenerator floor to crown	29 ft 11 in.
Volume of checkerwork	8825 cu ft

In deciding to build a new furnace, several innovations were incorporated which are not typical European practice. This sketch will enable the operator to compare European trends with those in the United States. All dimensions are metric.



Basic refractory materials are used for the bottom, for the front and back wall up to the uptakes, and for the wickets in the uptake end walls.

The bottom is made of a 3 in. course of insulating brick, one 3 in. course of second quality firebrick, two 3 in. courses of chrome brick, two 3 in. and one 4½ in. course of magnesite brick. On top of that is a layer of 12 in. dolomite, partly rammed with tar, partly burned in with open hearth slag.

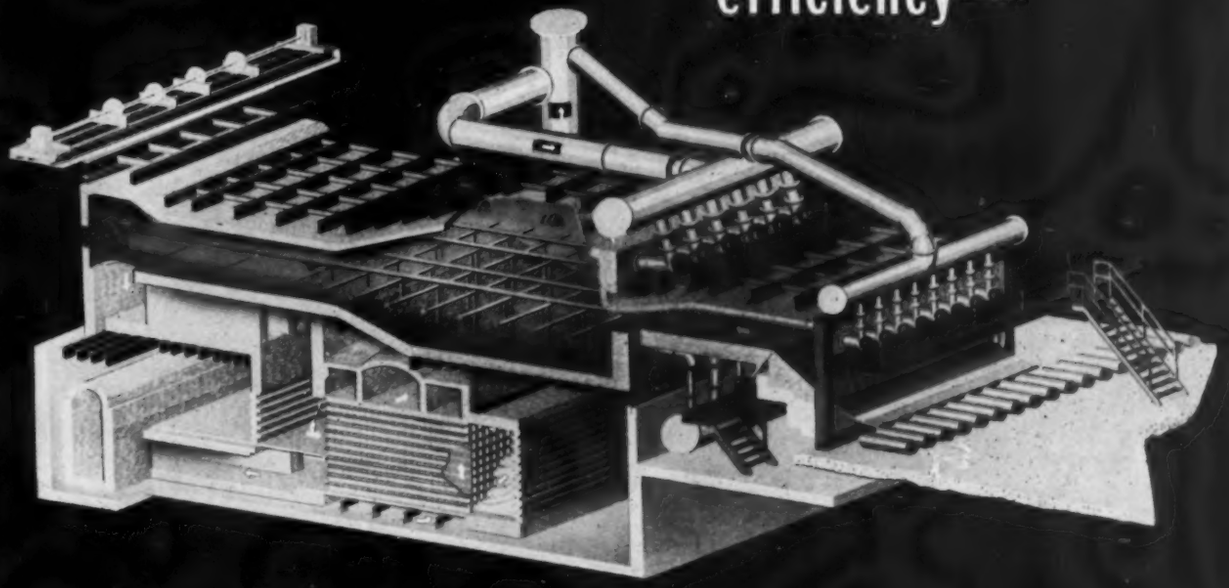
The silica roof is made of 15 in. wedge bricks with ribs of 18 in. The checkerwork consists of 70 layers 9 x 4½ x 2½ in. Peterson bricks (from top to bottom 20 courses superduty, 25 courses first class and 25 courses second class fireclay).

The furnace is equipped with instruments recording oil consumption, oil pressure, atomizing air pressure, combustion air volume, chimney draught, furnace pressure, temperature of the roof at three spots (opposite door 1, 3 and 5) and top temperature of the checkerwork.

Producing low carbon steel from a cold charge containing 20 per cent pig iron and 80 per cent scrap, operating records over a period of four weeks show an average of 15.6 net tons of ingots per hour, charge to tap, 10 minutes tapping time included.

The heat consumption per net ton of ingots was, over the same period, 4,110,000 Btu per net ton of ingots, excluding the fuel used for heating up and during delays. The heats, averaging 178 net tons of ingots, are tapped into two ladles because of crane limitations.

There's only one way to assure heating efficiency—



LOOK INTO

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CODE FOR BATTERY MAINTENANCE

By K. A. VAUGHAN
Manager of Field Engineering
Gould Storage Battery Corp.
Trenton, N. J.

▲ Maintenance is one of the few departments remaining where cost can be reduced. Although maintenance wages have increased along with production wages, very little effort has been made to control maintenance other than the reduction of maintenance personnel which is not the complete answer.

The ideal maintenance is preventive maintenance and naturally this must be controlled by supervisory authority especially in the general overall picture. Preventive maintenance is by far the cheapest. Not only does it extend the life of equipment, it also reduces lost time due to equipment failures which tie up the entire handling system.

In battery operated equipment the battery probably requires the least maintenance if it is properly supervised.

The following are the main causes of battery failures:

1. Improper charging.
   - A. Failure to give the battery sufficient charge after each discharge reduces the duty cycle.
   - B. Increases the time required to bring this overdischarged battery to a full charged condition which disrupts the entire battery charge system.
2. Failure to repair damaged cells.
   - A. This reduces the efficiency of the battery by reducing total voltage which means loss of speed and power.
   - B. Increases the drain on cells in good condition.
   - C. Damaged cells or cell removed from the circuit tend to damage the positive plate of the good cells.
   - D. Damaged or removed cells lower the voltage of the entire battery which is harmful to the motor of the truck under heavy load.
   - E. Failure to periodically wash batteries allows external short circuits to build up across the top of the battery reducing its efficiency.

There are various methods or systems used to control battery maintenance and one of the best is the daily battery record system which is as follows:

1. Each battery is numbered.
2. As each battery is installed in the truck, the specific gravity and temperature is read and recorded, time the battery is put into service is recorded, and the truck to which it is assigned is recorded.
3. When a battery is returned to its charging station the specific gravity and temperature is read and recorded, time is recorded, and the setting of the ampere hour meter together with a note as to whether evaporation was replaced or not is also recorded.

A quick glance at a chart of this type can tell the supervisor:

1. Whether the battery receives sufficient charge before being placed into service.
2. The number of hours the battery actually was in service.
3. Whether the battery was discharged below normal value.
4. A comparison of the specific gravity as read at the end of the discharge compared with the ampere meter setting and the ampere hour meter chart will tell at a glance whether batteries are being properly charged.

From a chart of this type a definite procedure can be established as to when batteries should be changed to prevent overworking them. By preventing overworking the battery the efficiency of the truck is increased and there is no lost time due to battery failure during the duty cycle. This chart also tells whether a battery was in full charge condition before it was placed in service, as failure to give a battery sufficient charge will also result in battery failure during the shift. The temperature reading of the battery before being placed in service will be an indication to you whether the proper charge rates are being maintained, because a battery with high temperature is an indication that the charge rates are too high. An investigation of this might prove that the reason for high charge rates is that cells have been cut out of the circuit, or that leaking or broken jars have caused the battery to become short circuited. Naturally, a battery in this condition will not do a day's work.

A few progressive users establish what might be considered a floating battery man who is equipped to test batteries on the job; and he visits all departments and buildings, checking the batteries while they are in service and from his experience he can tell approximately when the battery should be returned to a charge station. This is rather an expensive way of doing it. However, it gives an excellent opportunity to check up on charging conditions.

Under no condition should a production man be in charge of preventive maintenance, as experience has taught that they have very little regard for equipment. Their main goal is to get production at any cost and normally he has no responsibility for the cost of maintaining equipment.

One of the best examples of preventative battery maintenance is the telephone company. They pride themselves on uninterrupted service, and the equipment they use is not always the latest, most modern and up-to-date. However, regardless of age it is clean, well kept and operated with care. There is absolutely no reason why all equipment cannot be handled the same way, as the thousands of dollars saved by reduction of lost time more than pays for the cost of maintaining equipment in good working order.

Preventive maintenance on storage batteries must be started the day the battery is unpacked. At that time everyone charged with the operation of the battery should be made thoroughly familiar with the manufacturer's maintenance recommendations and these should be followed to the letter.

YALE & TOWNE MANUFACTURING CO. OPENS NEW PLANT

▲ On January 10th, the Philadelphia Division of Yale and Towne Manufacturing Co. opened a new and expanded plant for the production of materials handling equipment. Coincident with the opening of the new plant several new products were announced, one of which is a gasoline power industrial truck which is being added to the company's standard lines of electric powered and hand lift trucks.

The new plant, under construction during the past 2½ years, is located on a 93-acre site in northeast Philadelphia. The plant will be used for the production of industrial power and lift trucks, hoists, and scales which were previously built at the Tacony Street plant, in Philadelphia. The new plant which consists of a 17-acre, one story manufacturing structure was designed around its materials handling system, thus carrying out in its own operations the company's objective of increasing manufacturing efficiency by reducing materials handling cost.

The material flow layout of the new plant embraces the combined thinking of experienced manufacturing layout engineers with that of leading building and structural engineering organizations. As an example of the care and design in setting up the materials handling system, a typical part in the old plant had 22 operations and was moved 45 times over a total distance of 10,140 ft. In the new plant the same part moves only 3,380 ft for a saving of 67 per cent.

The plant layout was planned on eight basic requirements:

1. Adequate facilities to receive, inspect and distribute incoming material.
2. Short direct routes to and from storage and processing areas.
3. Proper arrangement of equipment to provide ample room for placing material within convenient reach of workers.
4. Quick access to machine and assembly benches for quick delivery and backup of material.
5. Grouping of machines in departments to minimize material movements and back-tracking.
6. Adequate storage facilities for material in process between operations.
7. Stockrooms with facilities to minimize handling.
8. Facilities to pack efficiently and to ship by all types of carriers.

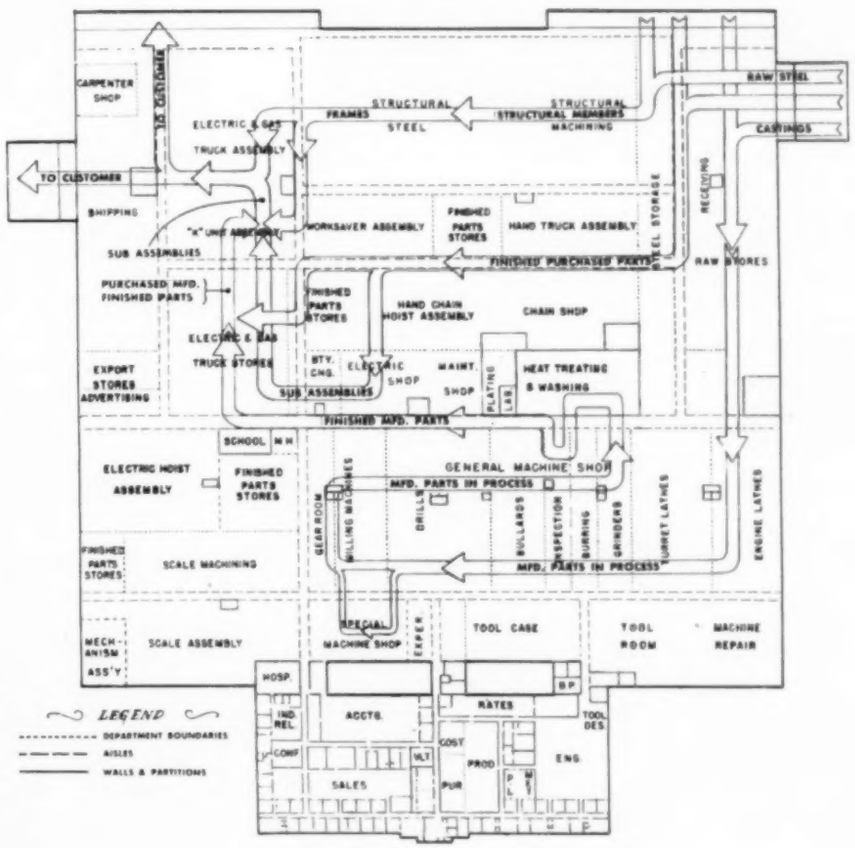
By satisfying these above basic requirements, the new Yale plant's materials handling system will move and store material efficiently with the least effort, greatest safety and in the shortest possible time. Planning this materials handling system required detailed study of the three primary factors of such a system:

1. Method of handling.
2. Equipment for handling.
3. The integration of the equipment into an overall system.

The increased production facilities of the new plant permit adequate production for the first time of the new dial scales developed since 1944 when Yale and Towne acquired the Kron scale business.

The total cost for plant equipment exceeded $15,000,000. It is designed to produce 20 per cent more than the old unit.

General flow chart of power truck products. Flow of materials was arranged to provide minimum movement and less cross-travel.



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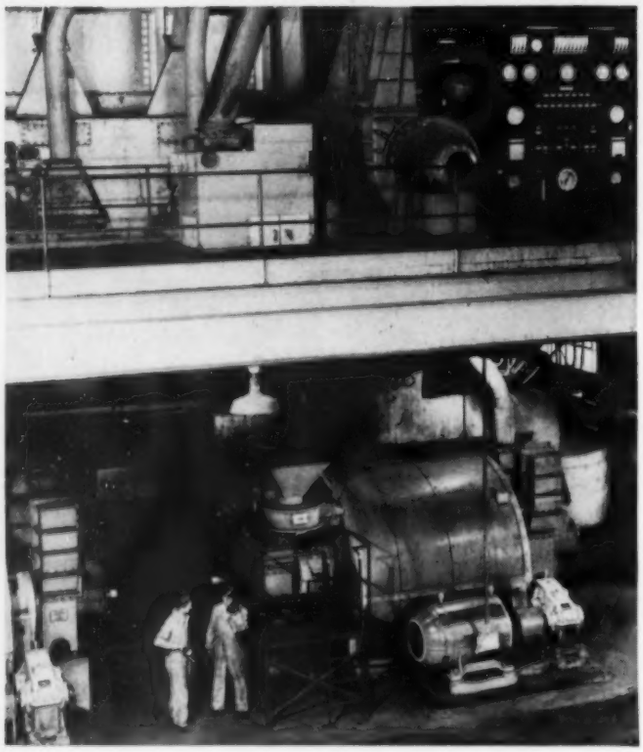

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Date-line Diary...

January 3

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 100.0 per cent for the week beginning January 3, 1949. This is equivalent to 1,802,500 tons of steel ingots and castings compared with 1,753,800 tons one week ago. This percentage rate is based on 1948 capacity.
▲ The Allegheny Ludlum Steel Corporation announced today downward reductions in some price extras of stainless steel. Quality extras were reduced from 5¾ to 1¾ cents per lb, and sheet gage extras were reduced also in some instances.
▲ The Edison Electric Institute announced that electricity production for 1948 was 336,000,000,000 kwhr compared with 307,000,000,000 kwhr for 1947. Of this, about 54,000,000,000 kwhr were produced by industrial and railway plants for their own use. Some 4,000,000 kw of new generating capacity were installed in 1948.
▲ Frank D. Newbury, consulting economist for Westinghouse Electric Corporation, predicts a gross national product of $260,000,000,000 for 1949 which is up $35,000,000,000 over 1948.
▲ The Anthracite Institute placed 1948 production at 54,100,000 net tons compared with 54,050,000 tons in 1947.

January 4

▲ The Lukens Steel Company was awarded a contract for about 750,000 lb of stainless clad steel for use on the Conemaugh River Dam.
▲ In 1949 the Marshall plan countries will spend a larger percentage of their money on equipment and raw materials for producing oil, steel and power and will use a smaller percentage on food.

January 5

▲ Sharon Steel Corporation will spend $4,000,000 in 1949 on their expansion program. $21,000,000 has been spent in the last three and one-half years. Net profit in 1948 was about $15 per share.
▲ The War Assets Administration sold a blast furnace and by-product coke ovens at Houston, Texas to the Sheffield Steel Corporation for a price of $7,150,000.
▲ CIO President Philip Murray stated that management was coming around to the union's point of view on the guaranteed annual wage.
▲ Domestic freight car deliveries in December totaled 9,967. Deliveries for the year 1948 totaled 112,634, the highest since 1924. Deliveries in 1947 were 68,552.
▲ President Truman in his State of the Union Message today asked Congress to authorize an immediate study of the adequacy of production facilities for materials in short supply such as steel, and if found necessary, authorize government loans for the expansion of such facilities. He also requested authorization to construct such facilities directly, if action by private industry fails to meet our needs.
▲ The Gray Iron Founders Society estimates that output of gray iron castings in 1949 will be about 11,000,000 tons.

January 6

▲ Blast Furnace H of Bethlehem Steel Company's Sparrows Point Plant, a 28 ft furnace, set a new world record for pig iron production in December with 54,336 tons.
▲ The American Iron and Steel Institute announced that steel making capacity is 96,120,930 tons per year, the highest in history. Ingot capacity was increased 1,800,000 tons in 1948. Present schedules call for a further addition of 2,200,000 tons in 1949, and 500,000 tons in 1950. Blast furnace capacity is now 70,500,000 tons.

January 7

▲ The F. W. Dodge Corporation stated that construction contract awards for 1948 were $9,429,618,000 for a new record which tops the 1947 volume by 22 per cent.
▲ Steel scrap prices have started to break and prices have slipped to $40 per ton in Chicago and to $41 a ton in Pittsburgh.

January 8

▲ The Census Bureau reports that employment reached a record average in 1948 of 59,500,000. Unemployment averages about 2,050,000.

January 9

▲ Under voluntary allocation, approximately 543,000 tons of steel a month will be on an allocation basis if present programs all go through.

January 10

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 99.3 per cent of the capacity for the week beginning January 10, 1949. This is equivalent to 1,830,600 tons of steel ingots and castings compared with 1,802,500 tons one week ago. This production will set a new record and the percentage is based on the new 1949 estimated capacity.
▲ Federal spending will total about $41,900,000 for the fiscal year starting July 1, 1949.
▲ The CIO advocated today income tax exemptions for a family of four earning less than $4,200 a year.
▲ The No. 4 seamless tube mill at the National Tube Company's Lorain plant started operation today.
▲ The first heat of carbon steel was poured today from the No. 1 electric furnace at the new Trenton, Michigan plant of the McLouth Steel Corporation.

January 11

▲ In a decision handed down by the Supreme Court, the Court decided that the provisions of the Taft-Hartley Law do not compel the employer to bargain with the foreman's union. They did this in effect by refusing to review a case brought up by the Foreman's Association of America.
▲ Legislation sponsored in the House and Senate would set up a $15,000,000,000 capital development fund in the RFC. This money would be loaned to private business or government agencies to achieve production goals and would enable the government to enter the steel business if it so desired.

January 12

▲ Official figures released on steel production in 1948 show that 79,302,575 tons of open hearth steel (94.8 per cent of capacity) 4,242,013 tons of bessemer steel (81.2 per cent of capacity), 4,964,495 net tons of electric steel (92.0 per cent of capacity) or a total of 88,509,083 tons of steel were produced in the United States in 1948. This is an overall rate of 93.9 per cent of capacity.
▲ In one of the two new plans for voluntary allocation of steel which the Department of Commerce announced would be put into effect in February, 2,576 tons of steel were allocated for manufacturing special railroad cars for carrying manganese bearing ore from South African mines to tidewater. One factor in this is the possibility of Russia cutting down exports of manganese ore.

January 13

▲ Federal Trade Commission stated today that they do not favor government regulation which will require a business to sell their products on an fob mill price basis. The commission believes that the anti-trust laws permit a single enterprise to use any pricing practice it chooses unless the practice involves price discriminations which injure competition.
▲ The American Iron and Steel Institute announced that the payroll of the iron and steel industry for the first eleven months of 1948 was $2,028,613,000 or $40,000,000 more than the total payroll for 1947. Employment attained a post war record in November with 646,200 employees. Earnings of non-salaried workers averaged $1.721 an hour which is a new high.

January 14

▲ Gwilym A. Price, president Westinghouse Electric Corporation, stated that the electrical manufacturing industry reached a new all time high level of production during 1948, exceeding 1947 by approximately 5 per cent in actual physical output.
▲ Edgar F. Kaiser announced that the Kaiser-Frazer Corporation is cutting back operations to one assembly line and reducing car output from 675 to 400 cars daily. He blamed the cutback on credit restrictions.
▲ President Truman stated that persons making $6,000 a year or more were those that he thought should pay higher income taxes. His definition of middle income starts at $6,000 per year and goes to $30,000.
▲ Weirton Steel Company set up a new pension plan which will mean a minimum retirement income of $100 a month for those employees who participate.

January 15

▲ The Esso Standard Oil Company and the Shell Oil Company cut prices of heavy fuel oil up to 25 cents a bbl. This is the third general reduction in 6 weeks.

▲ The government filed suit against the American Telephone and Telegraph Company to force them to give up ownership of the Western Electric Company. The suit is a civil anti-trust action.

▲ Stockholders of the Copperweld Steel Company approved an agreement under which both the privately owned and government owned steel making facilities at Warren, Ohio will be sold as a single unit.

▲ Youngstown Sheet and Tube Company announced that they will spend $16,000,000 on additions and improvements in 1949. This is about double that spent in 1948. One of the major items is a continuous butt weld tube mill in the Chicago area.

▲ The Sharon Steel Corporation will spend $4,000,000 on its improvement program in 1949. Part of this will go towards a new tube mill at the Farrell Works.

January 16

▲ It is believed that unions will emphasize pension and welfare programs in their negotiations this year because of the drop in indices for the cost of living.

January 17

▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 100.0 per cent of capacity for the week beginning January 17, 1949. This is equivalent to 1,845,400 tons of steel ingots and castings compared with 1,830,600 tons one week ago. This week's production will set a new record.

January 18

▲ The Lone Star Steel Corporation is applying to the RFC for a $65,000,000 loan to expand its facilities at Daingerfield, Texas. Several open hearth furnaces as well as finishing facilities will be included in the expansion which will make it the first steel finishing plant of its type in the Southwest.

▲ Wm. Holaday, research director of the Socony-Vacuum Oil Company, urged home owners and industry not to use oil if they can easily get natural gas or coal. This recommendation was made to preserve petroleum resources.

January 19

▲ Irving S. Olds, chairman of the board, United States Steel Corporation, stated in an address that he felt that eventual nationalization of the steel industry along British lines may be in the minds of some of the critics of the steel industry.

January 20

▲ Secretary of Commerce Sawyer warned that the high scrap stocks on hand should not make the industry optimistic because consumption is now higher.

January 22

▲ The Bethlehem Steel Company plans to increase coke oven capacity at Sparrows Point 17 per cent by the addition of a 65-oven battery.

January 23

▲ The Penn-Warren Steel Corporation of Wilmington, Delaware offered $10,400,000 for the steel plant at Warren, Ohio owned jointly by the government and the Copperweld Steel Company. This bid was turned down by Copperweld. Another new company the Warren-Ohio Steel Company headed by Paul V. McNutt, said it would like to negotiate if bids are not acceptable.

▲ American importers were told that their imports of manganese ores from Russia would probably be stopped when their present contracts expire.

▲ The Acme Steel Company has started operations on a new five-stand, cold strip mill. The mill will roll sheets in gages of 0.006 to 0.02 in. and in widths up to 18½ in. and at speeds up to 3000 fpm.

January 24

▲ Steel scrap prices dropped another $2 a ton to a new figure of $39 in the Pittsburgh area.

▲ The Board of Directors of the Lukens Steel Company approved an appropriation of $266,000 for a new soaking pit which will replace the present two regenerative pits.

▲ Blast furnaces in the United States and Canada consumed 7,351,059 gross tons of Lake Superior iron ore in December for accumulative total for the year 1948 of 80,629,057 tons. Iron ore stocks at lower lake ports on January 1st totaled 39,460,497 tons compared with 36,094,970 tons one year ago.

▲ The operating rate of steel companies having 94 per cent of the capacity of the industry will be 101.1 per cent of capacity for the week beginning January 24, 1949. This is equivalent to 1,863,800 tons of steel ingots and castings compared with 1,845,400 tons one week ago.

January 25

▲ Brass and bronze ingot prices were cut from ½ to 1 cent a lb by a leading producer.

▲ The American Iron and Steel Institute stated that the industry spent $583,000,000 in 1948 to expand and improve production facilities. Expenditures in 1949 will total about $627,000,000. Ingot capacity should be expanded 2,200,000 tons in 1949.

▲ The House Labor Committee opened hearings today on a bill to raise the minimum wage rate from 40 to 75 cents an hour.

January 26

▲ United States Steel Corporation reported a dividend of $1.25 per share on the common stock as well as a special dividend of $1 per share. Income for 1948 is reported as $129,552,424 or 5.2 per cent on sales. The board of directors also recommended a three for one split of the common stock. Net profits per share was $11.99 compared with $11.70 in 1947.

▲ Alan Wood Steel Company in a preliminary report stated that 1948 earnings are about $4,100,000 or $7.75 per share.

▲ Secretary of Commerce Sawyer stated in a hearing before a Senate Banking sub-committee that the Administration will soon ask for mandatory powers to control distribution of steel and other basic products in short supply.

▲ The Inland Steel Company reported net income for 1948 was $38,606,899 (9.83 per cent of net sales) or $7.88 per share of stock.

January 27

▲ Pig iron production in December was 5,525,000 net tons or higher than in any previous month in war or peace. The total for 1948 was 60,136,000 tons for a new peacetime record.

▲ The Wheeling Steel Corporation reported earnings of $23.24 a common share for 1948 for a total of $15,050,045.

▲ The Briggs Manufacturing Company purchased the Upper Union Mills of the Carnegie-Illinois Steel Corporation in Youngstown, Ohio. They have thus abandoned their plans for locating a plant in the Pittsburgh district.

▲ Marketed production of natural gas in 1947 in a report just released by the Bureau of Mines was 4,444,693,000,000 cu ft or 10 per cent over the peak in 1946.

January 28

▲ Eugene G. Grace, chairman of the Bethlehem Steel Corporation, stated that overall demand for steel has softened, although there have been important cancellations in steel orders. He believes, however, that Bethlehem will continue to operate full capacity for the first six months of 1949.

▲ Mr. Truman stated that he has always contended that steel prices are too high and still thinks this is the case.

January 29

▲ Automobile and truck output in the United States and Canada for the first four weeks in January was 440,341 units compared with 432,125 one year ago.

▲ Commerce Secretary Sawyer stated that export controls may be lifted if this year's harvests are as large as expected. He stated, however, that rigid export controls should be maintained on steel, aluminum, copper, meat and some fats and oils.

January 30

▲ Commerce Secretary Sawyer urged whole-hearted industrial participation in the national drive to uncover iron and steel heavy scrap.

January 31

▲ National Steel Corporation in a preliminary report for 1948 reported net income of $40,121,506 or $16.35 a share.

▲ The Jones and Laughlin Steel Corporation reported a net income for 1948 of $31,222,451. This is equivalent to $12.01 a share compared with $7.17 for 1947.

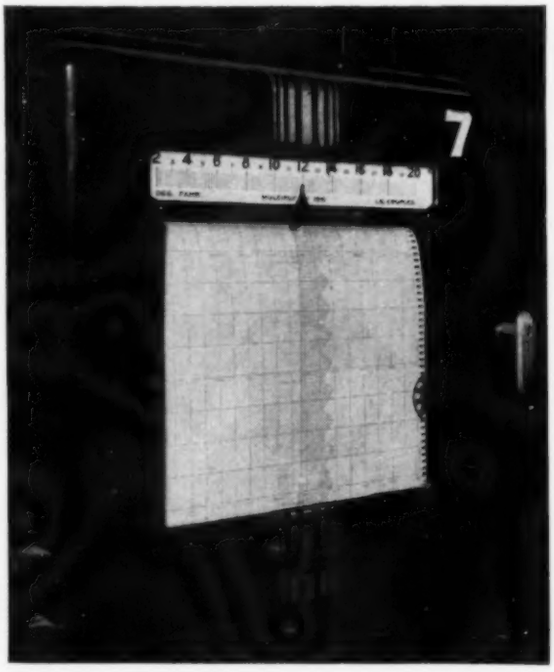
▲ The operating rate of steel companies having 94 per cent of the steel capacity of the industry will be 100.9 per cent of capacity for the week beginning January 31, 1949. This is equivalent to 1,860,100 tons of steel ingots and castings, compared to 1,863,800 tons one week ago.

▲ Secretary of Labor Tobin asked Congress to repeal the Taft-Hartley Law and replace it with a revised Wagner Act. The new bill would allow closed shops. It also provides for a thirty day cooling off period for disputes threatening national welfare.

▲ The Superior Court has agreed to revise the court ruling which upheld the FTC order which ended the use of the basing point system in the rigid steel conduit industry. The case should be decided by next July.

Some of the 40 cover furnaces at Great Lakes Steel Corp., Detroit, Michigan. Center, stacks of flat sheet stand ready for heating; right, completely assembled cover furnaces carry on the annealing process; left, inside covers protect the annealed steel during cooling.

Annealing Covers at Great Lakes Get Accurate MICROMAX Control



This Micromax record demonstrates one type of control. Irregular right margin shows the fluctuating temperature at the roof, as fuel is turned on and off. Left margin shows regular increase in temperature of the work.

To help take full advantage of the economies possible with forty cover furnaces annealing a tremendous output of sheet and coil steel, Great Lakes uses Micromax pyrometers for the temperature control part of the job.

Temperature cycles for some of the heating operations are fairly complicated. Sometimes the controller must bring the work up to temperature smoothly and efficiently and hold it at soak temperature for exactly the prescribed period. For cycles like malleablizing or spheroidizing, Micromax also controls the cooling rate. Great Lakes is equipped to accomplish almost any variation of the basic annealing cycle, and Micromax Control handles all requirements.

Program Control effects substantial improvements in fuel economy and product quality, because it regulates valve movement at the most critical times — when furnace temperature is changing at a predetermined rate.

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Industry News...

STEEL INDUSTRY TO SPEND $627,000,000 FOR NEW EQUIPMENT DURING 1949

▲ Companies of the iron and steel industry spent a record amount, totaling $583,000,000 during 1948 to expand and improve their production facilities, American Iron and Steel Institute announced recently.

Even more money will be spent this year, the Institute said. The expenditures will be raised to a total of $627,000,000.

A total outlay of more than two billion dollars will have been made by the end of this year for postwar expansion and improvement. At that time it is expected that annual steelmaking capacity will be at a record high level exceeding 98,300,000 tons. An additional 500,000 tons will be added in 1950.

The huge total outlay last year enabled the companies to increase their combined steelmaking capacity by more than 1,887,000 tons. In addition to constructing and improving steel furnaces, the companies increased the capacities in their blast furnace, coke oven, and other raw material departments and added to processing and finishing facilities in order that the additional raw steel could be made into useable finished products.

This year's plans for a record outlay of $627,000,000 will increase steel capacity by about 2,200,000 tons, and provide necessary facilities to roll that additional steel into finished products.

The Institute cited a comparison to illustrate the sharp increase in the cost of expanding and improving facilities. The amount spent last year, when 1,887,000 tons of capacity was added, was more than four times greater than ten years earlier when about 1,600,000 tons were added to raw steel capacity with the companies' expenditures totaling only $140,000,000.

NEW STEEL COMPANY ORGANIZED IN ST. LOUIS

▲ A newly organized steel company named Western Reserve Steel Corp., was announced recently by Harry H. Holloway, president. The new company plans to build a complete seamless tube mill, which will be the first step toward what may become an integrated steel plant at Madison, Ill. (near St. Louis). Plans call for an initial outlay of $7,000,000 and for the rolling of 30,000 tons of oil well casing a month by the third quarter of 1949. The new company has a number of customers in the oil business and will not sell steel in the open market for several months. It is con-

MECHANICAL CAR UNLOADER SPEEDS UNLOADING

The Kinney car unloader is shown, at the left, mechanically unloading ore at the Jones & Laughlin Steel Corp., Pittsburgh, Pa. At the right, the unloader is seen in operation on a carload of coal at a public utility central station. Manufactured by Heyl and Patterson, Pittsburgh, Pa., the unloader operates efficiently on frozen carloads of coal or ore.

Principally, the unloader consists of a movable bridge equipped with a trolley which carries the unloading ram. A specially designed bridge is used which may be run on a crane runway or may be designed as a gantry or other type of bridge. The ram head, which oscillates by a swinging movement of the ram and by moving the bridge, is equipped with a wide-faced spade type tool suitable for unloading ore, coal, slag, clay, or other bulk materials from hopper cars. The tool is removable and can easily and quickly be replaced by other tools. One man can unload a 70-ton car of iron ore in 20 minutes where formerly 6 men required 30 to 40 minutes.

templated that one tube mill will be in operation within three months and a second mill within six months. Western Reserve will purchase tube rounds temporarily, but will be making its own steel within six months.

The company has acquired two government owned plants in the midwest from the War Assets Administration. The property acquired consists of two plants under one roof, and include 110 acres of land. The site was formerly a steel foundry for heavy castings. Buildings include a factory with floor area of over 1,200,000 sq ft, an open hearth furnace building, an office building, a chemical laboratory, two machine shops and a welding shop. The present plans include the installation of four 70-ton electric furnaces and four 20 kva transformers. Calumet Steel Co. will supply tube rounds for the time being.

SCRAP FROM SLAG PILES TOTALS 2 MILLION TONS

▲ Slag piles in steel plants are giving a big assist in licking the scrap shortage. These slag piles are currently yielding scrap at a yearly rate of some two million tons. Since the steelmaking formula calls for roughly half scrap and one-half pig iron, the two-million-ton scrap total is enough to make possible the production of four million tons of steel.

Before 1939 only about 10 per cent of the steel companies scavenged their dumped slag.

The job of combing through the heaps is turning into big business for the people whom the steel mills hire to handle it.

Biggest operator in the field is Heckett Engineering, with headquarters at Butler, Pa. This firm's haul from waste piles is about 20,000 tons of scrap a month. The company currently works Republic Steel Corp.'s dumps at South Chicago, Warren, Ohio, and Gadsden, Ala. It sifts the slag at Youngstown Sheet & Tube's Indiana Harbor, Ind., plant and at the Birmingham plant of the Tennessee Coal, Iron and Railroad Co. Other Heckett customers: The Newport Rolling Mills division of International Detrola Corp. at Newport, Ky., and the Steel Co. of Canada at Hamilton, Ont.

Another big slag-combing outfit is Brown Bros. Construction, Inc., an offspring of the Heckett organization. The Brown brothers, who used to work for Heckett but set up their own outfit after the war, collect from 3,000 to 3,500 tons of scrap a month from dumps at Phoenixville, Pa. (Phoenix-Apollo Steel Co.) and at Coatesville, Pa. (Lukens Steel Co.) among others.

Carnegie-Illinois Steel Corp. employs Robert M. Chambers, a private contractor, to dig out about 5,000 tons of scrap a month from its Gascola dump, near Universal, Pa. A 1,500 monthly scrap harvest is being reaped by Armco Steel Corp. from old or abandoned dumps at Butler, Ashland, Ky., and Middletown, Ohio.

From dumps where waste from its open hearth furnaces is now being discarded, Armco reclaims about 12,000 tons of scrap a month. About half of that metal goes into blast furnaces where its 35 per cent iron oxide and 40 per cent lime content makes it a valuable ingredient in the brewing of pig iron. The other half is being stored for future use; its high manganese content will prove important when the company is forced to begin using taconite ore, an iron-bearing rock low in manganese, as high grade ore supplies are exhausted. (In some types of steel, the amount of manganese required is extremely small but when high resistance to impact is desired as much as 14 per cent manganese may be needed.)

DULUTH PLANT CAPACITY INCREASED 35 PER CENT

▲ Steel capacity at American Steel & Wire Co.'s Duluth works will be increased 243,000 tons a year, or 35 per cent, as a part of a replacement, improvement and rebuilding program. In the open hearth steel-producing department, replacement will be made of two furnaces which were partially dismantled and taken out of service during the business recession of the 30's. The new replacement furnaces will be of the same size as the furnaces presently in use in this plant, and will be erected in the existing building on foundations which were used for two previous furnaces. They will produce standard open hearth steel according to customers' specifications.

To handle the additional ingot tonnage, the works will establish one row of soaking pits on the site of the pres-

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There's plenty of Oxygen in the air and you can extract what you need, as you need it, by leasing Air Products generators and making your own.

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With Air Products generators, your OXYGEN flows from the generator, through your pipe line, to the points of use, without handling.

You control your own supply and remove the risk of costly shut-downs which often result from delivery failure.

You eliminate the cost of handling, delivery, evaporation loss and selling cost, which is a large percentage of the total cost.

If you use over 200,000 cubic feet per month, you can assure your supply at low cost, without capital investment for equipment, by leasing Air Products generators and making your own oxygen from air. These same generators also produce high-quality nitrogen gas.

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Let us know how much OXYGEN you use per month, minimum and peak demands, whether you own a pipe line and storage bank, and any other pertinent information. We will show you how to make very substantial savings, as many other firms have done. Names on request.

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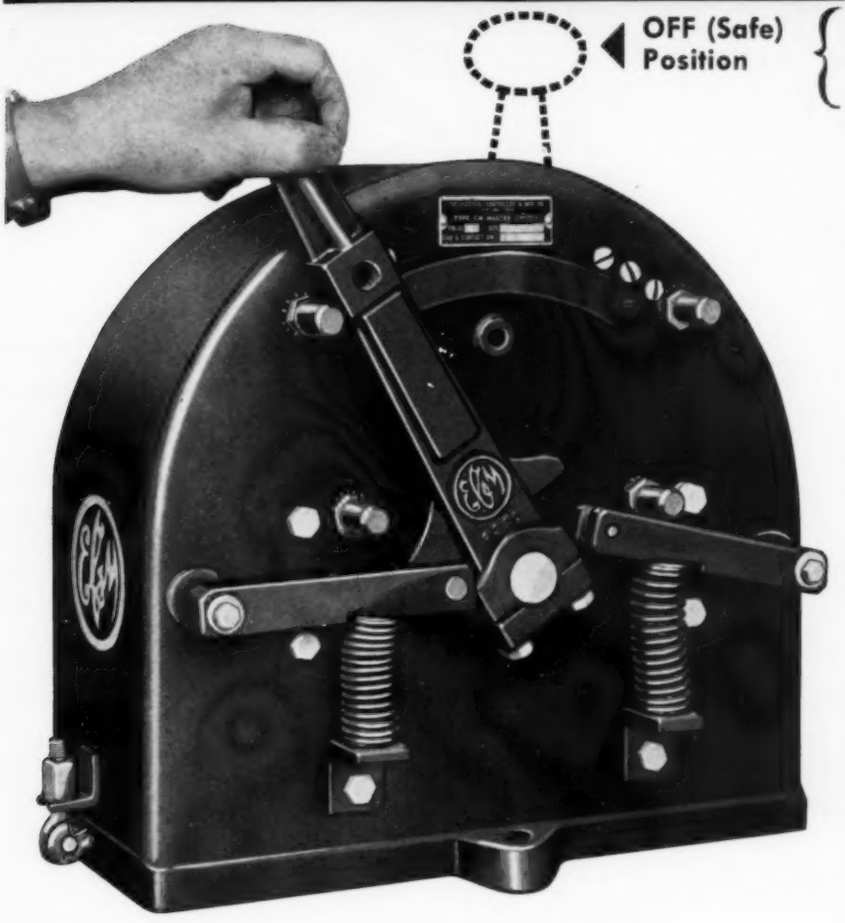
OXYGEN GENERATORS

Master Switch *automatically* returns to Off-Position from any speed-point in either direction . . .



Provides Safe Operation should operator fall or otherwise remove his hand from master-handle.

There are several *speed-control* applications where *safe* practice dictates that power be automatically disconnected from the motor-driven machine the instant the operator leaves his station or for some other reason removes his hand from the master switch. A typical example is a transfer (or larry) car with a *spring-return* master switch mounted on the side within reach of the operator as he walks along with the car. Should he trip and fall, the master switch automatically centers itself in the off (safe) position.

The EC&M Cam-type Master Switch (as illustrated) is ideal for this service because of the *short-throw* of the operating handle. From the "full-on" to the "off" position, the handle of an EC&M Master travels less than 40° from the sixth speed-point in either direction to the off (central) position. There's nothing to equal the EC&M Cam Master Switch for spring-return service.

Make your own Compact Layouts with EC&M Bulletin 1190 Cam MASTER SWITCHES

in Crane-cabs or Mill-pulpits

For new installations or when re-vamping existing equipment, take advantage of the narrow width and short-throw of EC&M Cam Master Switches for improved performance. These features appeal to operators.

Write for Bulletin 1190 giving details of these short-throw, narrow width Masters

THE ELECTRIC CONTROLLER & MFG. COMPANY

2698 E. 79th STREET — CLEVELAND 4, OHIO

ent warming pits in the existing building. Rolling mill output will be increased from an annual total of 580,000 tons of billets produced on the plant's 40-28 in. mill to 784,000 tons.

Replacement of 57 of the plant's coke ovens will be included in the program. The original coke oven battery, built in 1916, comprised 90 ovens and has been in constant use since that time. Under the present program, 57 of the ovens will be replaced by a battery of Koppers design and will incorporate the same method of gun-type firing as the original ovens; however, the 57 ovens will be equipped with self-sealing doors and will use burners of a modern and more efficient design.

Construction of the new ovens is expected to begin soon, and the new unit will be located south of and adjacent to the existing ovens in order to maintain coke production during the construction period.

Coke is made from coal brought to Duluth from lower lake ports, which also ship limestone to the Duluth works. Iron ore from Minnesota, together with coke and limestone, is required for the production of pig iron.

In the annealing department of the Duluth works, pot type annealing furnaces will be replaced by modern circular bell-type furnaces which will permit closer heat control during the annealing period to greatly improve the quality of the steel wire produced at the plant.

To keep pace with the works' expanded output of steel, necessary auxiliary equipment such as ladles, charging buggies, mold cars, and cinder pot cars will be modernized.

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for Steel Mills and Industrial Furnaces

Bloom Engineering Company designs and manufactures combustion equipment for steel mill and industrial furnaces. The correct application of these products is an important part of our service to customers.

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- Hot Air Burners
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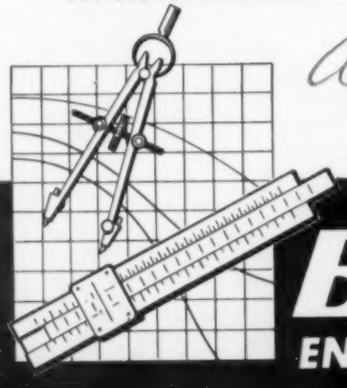
- Steam-Oil Pressure Ratio Regulator
- Bloom Time Cycle Reversal Systems for Open Hearth Furnaces



Write for bulletins on any of the above Bloom Equipment.

BLOOM ENGINEERING CO., INC.

857 W. North Avenue Pittsburgh 12, Pa.

BRAZIL TO EXPAND VOLTA REDONDA PLANT

▲ Brazil plans a threefold expansion of its Volta Redonda national steel plant in 1949.

General Silvio Raulino de Oliviera, president of Volta Redonda, will arrive in the United States shortly, according to the Brazilian Government Trade Bureau, to work out plans for increasing present capacity of the plant until Brazil can meet the country's industrial requirements out of its own steel output.

The mill is expected to reach capacity production by the end of February, 32 months after the first steel flowed from the plant on June 23, 1946. Production at capacity will amount to 250,000 metric tons of steel annually. Together with Brazil's 24 other steel mills, more than 40,000 metric tons a month will be produced.

Total production will amount to slightly more than one-half Brazilian steel consumption, but industrial needs are growing so rapidly that Brazil probably will continue to need foreign steel even after the capacity of Volta Redonda is trebled.

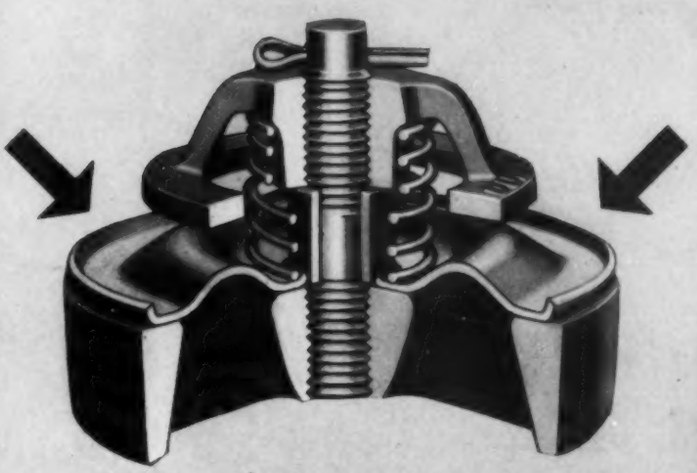
Brazil's steel production in 1939 was only 114,095 metric tons, while by 1947, with Redonda entering the field, it was up to 388,000 tons. Total 1948 Brazilian output is estimated at 475,000 tons.

FONTANA PLANT PRODUCES 853,000 TONS IN 1948

▲ A record-breaking 853,000 tons of steel ingots were produced at the Fontana plant of Kaiser Co., Inc., in 1948. This was a substantial increase over the previous record of 796,000 tons attained in 1947. Shipments of finished steel products from Fontana totaled 615,000 tons. These records

DURABLA

Valve Member Utilizes Arch Construction For Strength But Can Flex To Adjust To Any Slight Variations In Plane Of Valve Seats.



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The patented arch construction Durabla Valve Member* retains sufficient flexibility, despite its great strength, so that the valve-to-seat contact maintains a constant pressure-proof seal. The Valve Seat is rigid, the Valve Member is freely mounted. Hence the free member accommodates itself to wear of the valve parts which may occur in severe service.

Since the Valve Member is freely mounted, a unique feature of Durabla engineering, it can turn about the Guard-Stem and a self-grinding pressure-proof seal is always maintained. Lower maintenance costs; Infrequent need for inspection; Minimum lost time for repairs are all achieved through the use of Durabla "The Valve That Grinds Itself."

Address DURABLA Engineering Department for Information and Bulletin No. 952

* Patent Numbers 2090486, 2117504

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THREE TIMES THE LIFE OF ORDINARY MAGNET CHAIN!

75th ANNIVERSARY ★

TAYLOR MADE Chain

MANUFACTURERS OF BBB, PROOF COIL, HI-TEST AND STEEL LOADING CHAIN

were made despite the fact that the Fontana blast furnace, after running for 5½ years and producing over 2,000,000 tons of pig iron, was shut down for relining in late summer of 1948 for a period of 63 days.

Keeping pace with the new steel production records, the large scale expansion of new steelmaking facilities at Fontana made notable strides during 1948. In the early part of the year production was begun in the new cold rolled strip mill and in the new continuous weld pipe mill.

On December 24, the first heat of ingots was tapped from the seventh open hearth. With this additional steelmaking furnace in operation, it is anticipated that steel ingot production in 1949 will top 1,000,000 tons.

The completion of the Eagle Mountain railway made it possible for Fontana to draw iron ore from the vast Eagle Mountain deposit only 164 railroad miles from Fontana. Delivered ore costs at Fontana are now among the lowest in the country, Mr. Kaiser stated.

Late in 1948 ground was broken at Fontana for a new blast furnace and an additional battery of coke ovens. At the present time the Fontana plant is the only one on the Pacific Coast with a blast furnace.

Among the new facilities which will be completed at the Kaiser Steel plant during 1949 is an additional slab heating furnace which will permit an augmented plate output. Construction of facilities at Fontana to produce hot rolled sheets up to 78 in. wide with a minimum of 14 gage thickness is well under way. The new mill is expected to produce 100,000 tons a year of both coils and flat sheets for heavy sheet metal work, barrels, oil and domestic water tanks, pipe, auto frames, and a host of like fabricated articles. Likewise, the year 1949 will see the first production from the new electric weld pipe mill being constructed at Fontana, capable of producing 100,000 tons a year of steel pipe from 5 in. to 14 in. in diameter.

SHEET & TUBE SPENT $8,750,000 IN 1948

▲ During 1948 Youngstown Sheet and Tube Co. spent an average of nearly three-quarters of a million dollars every month for additions and betterments to plants and equipment

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. . . they're mighty interesting, and more common than you might think. Just like other machinery that goes into heavy industry, conveyers sometimes break up under severe service. When that happens, there comes a series of shirt-sleeve sessions aimed at determining just why the job went bad. Sometimes it proves to be materials that are at fault; again, careless operators might be to blame; but much more often it develops that the equipment, for one reason or another, just wasn't designed heavy enough in the first place. But whatever they might prove—these long reviews of the details of a bad job—they are all part of the experience of seasoned conveyer people.

Most steel plant engineers find that it is pretty sound judgment to depend on conveyer people who have many years of such experience behind them—people who started years ago handling "heavy" coils which weighed 8,000 lbs., and who today are building equipment to handle those which weigh 25 tons—people who know why the good systems stayed on the job, and why the bad ones couldn't stand the gaff.

Give your heavy handling problem the attention it deserves. Take it to Mathews' Engineers, and let them go the limit in building into the job the weight required. It will pay off in long, trouble-free service.

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Engineering Offices or Sales Agencies in Principal American and Canadian Cities

and to protect future supplies of raw materials. Total expenditures during the year amounted to $8,750,000.

Plans for 1949 call for an even higher expenditure — $16,000,000 or an average of $1,250,000 per month. Major projects for the next 12 months are:

CAMPBELL WORKS

Completing the No. 5 boiler house extension and installing one boiler.

Install new tar percipitators and build a surplus gas holder at the coke plant.

Two reaming machines and a roll lathe for seamless tube mills.

Installing an air compressor and piping in No. 7 electric sub-station.

Building an extension to the rod mill building at Struthers.

BRIER HILL WORKS

New bull blocks, cut-off and straightening machinery, and pointers for the cold drawn bar department.

New pull-out stands and plate edge blasting equipment for the electric weld tube mill.

Two diesel locomotive cranes.

INDIANA HARBOR WORKS

Install a continuous butt weld tube mill.

A new continuous furnace for the 10-in. skelp mill and additional stands to increase output.

Additional work on No. 1 blast furnace which was rebuilt during 1948.

Two new charging machines, a scrap baler and a new wash and locker building for the open hearth department.

Completing the blast furnace fuel system and installing a new approach table and ingot turnover in the blooming mill.

New billet conditioning equipment to handle 40-ft bars at the No. 10 merchant mill.

Alterations to the hot strip mill to handle thick slabs.

Install a two-stand temper mill in the cold strip department.

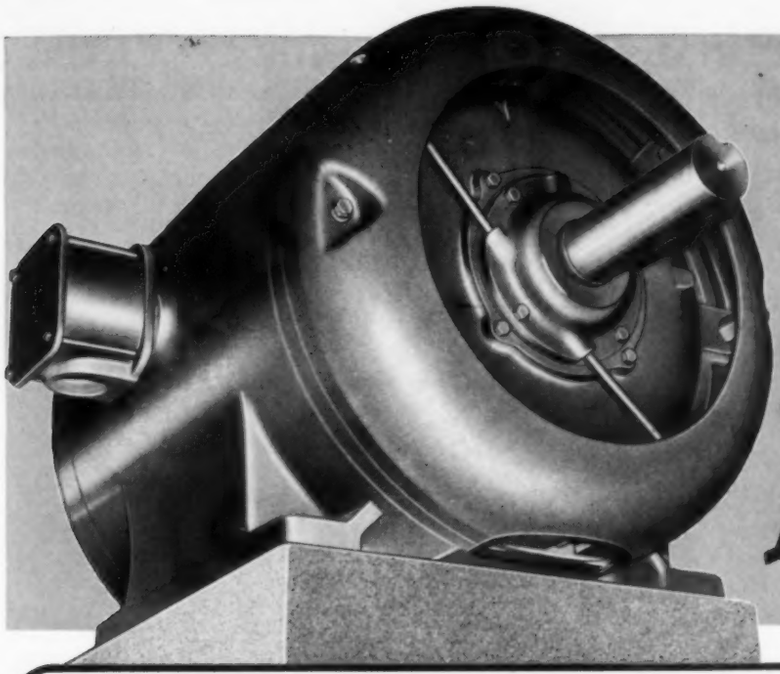
Provide electrolytic reflow power in the tin mill.

Extending the power house building and installing turbo-blowers.

Three new diesel locomotives.

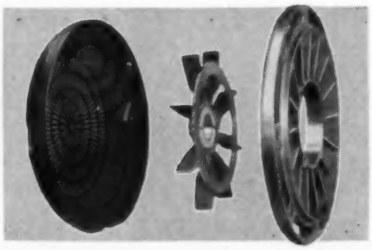
The company's biggest project last year was rebuilding No. 1 blast furnace at Indiana Harbor. The new furnace, with a rated capacity of 1400 tons of iron per day, went into blast in mid-September and replaces an 800 ton stack.

Major project in the Youngstown

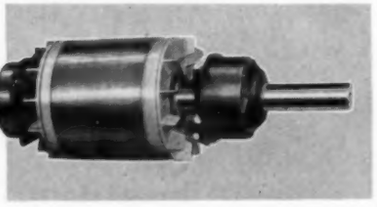


Wagner
Totally-Enclosed Fan-Cooled Motors
Built for your Protection

here's the Inside Story!



Fan shield, which protects externally mounted, non-ferrous ventilating fan; and front endplate, ribbed for mechanical strength.



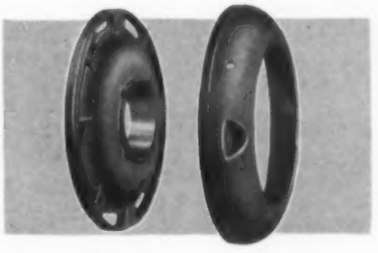
Cast aluminum rotor with cartridge-type ball bearings.

Wagner totally-enclosed, fan-cooled motors are designed for a particular purpose—to operate efficiently and safely in atmospheres filled with dust, fumes, moisture, explosive gases and combustible substances. These motors are approved by Underwriters' Laboratories for Class I Group D and Class II Groups E, F, and G hazardous locations. The photographs indicate the painstaking care with which these motors are built for your protection. They are available in ratings up to 200 horsepower, and are varied electrically to suit a wide variety of application requirements. Bulletin MU-185 gives information on the complete line of Wagner Motors.

BUYERS OF WAGNER MOTORS GET NATIONWIDE SERVICE! More than 450 Wagner Authorized Electrical Service Stations and Parts Distributors augmented by 25 Wagner-owned Service Branches are ready to immediately supply on-the-spot service, factory guaranteed exchange motors, or genuine Wagner parts. Write for Bulletin MU-24 for complete list.

Wagner Electric Corporation
6483 Plymouth Ave., St. Louis 14, Mo., U. S. A.

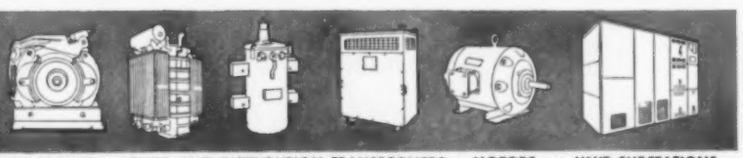
Wound stator, showing extra large air ducts.



Back endplate, and shield which directs ventilating air so that it cools the drive-end bearing.

Consult Wagner Engineers on all Electric Motor Problems

Wagner Electric Corporation
EST. WE 1891



BRIDGE BRAKES • POWER AND DISTRIBUTION TRANSFORMERS • MOTORS • UNIT SUBSTATIONS
ELECTRICAL EQUIPMENT AND AUTOMOTIVE BRAKE PRODUCTS

M49-7

district was the installation of new blooming mill cranes. Work was begun on the boiler house extension and the coke plant tar percipitator.

GRANITE CITY STEEL SETS ALL-TIME RECORDS

▲ New all-time production and shipping records were established by Granite City Steel Co. during 1948. During 1948, the company produced 494,000 ingot tons— an increase of approximately 12 per cent over the 1947 total of 440,000.

The over-all increase in steel shipments was even greater than the jump in production. Some 409,000 tons of steel were shipped in 1948 compared with 345,000 tons in 1947. This is an increase of almost 19 per cent.

The difference between the total number of tons produced and the total shipped results from a loss of steel in processing ingots. Processing ingots into finished products creates scrap which is fed back into the furnaces, with other material, to make new steel.

Previous record-year for the mill was 1944, the period of peak wartime industrial activity, and the year in which the entire steel industry achieved its top performance.

Granite City Steel turned out 488,000 ingot tons in 1944. It increased this tonnage by approximately 1 per cent in 1948, while the steel industry as a whole turned out somewhat less tonnage in 1948 than it produced in 1944.

Major factor in the record-breaking year for Granite City Steel is the completely modern and efficient equipment being used by the company's mills. In the past decade, the company has spent nearly $20,000,000 on modernization, expansion and improvements. In addition, it is operating, under government lease, open hearth facilities which were built at Granite City during the war at a cost of $12,700,000.

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INDIA TO SPEND $60,000,000 IN U. S.

▲ India will spend approximately $60,000,000 in the United States for iron and steel manufacturing plants and fabricated steel frames in 1949, 1950 and 1951 in a vast program of industrialization, which should make that country America's best customer less than two years after gaining its independence. India's total expenditures in the United States during the three-year period will total about a half billion dollars, mostly for capital goods according to the Hon. Ramji Ram Saksena, Indian Consul General in New York.

Part of India's industrialization program is the construction of several huge hydro-electric projects which will be used to reduce the cost of power for industry and also serve to increase India's useful acreage. India's present steel capacity of two million tons annually will be doubled as part of the plan.

The report states that India has the dollars with which to make these purchases in the United States. Other products to be purchased by India in the United States include railroad equipment, trucks, ships, machine tools, electrical machinery, office machinery, paper and pulp mill plants, etc. To encourage the industrialization program, Mr. Saksena reported, the Government of India has drastically reduced the import duty on plant machinery and new industry has been given many income tax reductions.

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PARALLOY STEEL MILL ROLLS

More Tons Per Pass

STEEL MILL EQUIPMENT

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The Youngstown Foundry & Machine Co.

YOUNGSTOWN, OHIO

SHARON TO ADD TWO WELDED TUBE MILLS

▲ Sharon Steel Corp. will spend $4 million this year for expansion and improvements. This is part of a $25 million program, of which Sharon has spent $21 million in three and one-half years on expansion.

The 1949 expansions include installing two more electric weld tube mills at the Farrell works. The program also includes finishing the 14-in. strip mill at Farrell, which greatly increases Sharon's capacity for producing highgrade strip which is in big demand.

Last year, Sharon sold its seamless pipe mill at Dearborn, Mich., to the McCarthy International Tube Corp. of Houston, Texas. The new Sharon installations will make up for the pipe capacity the company lost in this sale. The installations will be much more economical to operate, also producing a different type of pipe.

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The bulletin illustrated is not just a piece of sales literature but a complete 24 page treatise on the instrumentation and automatic control of steel making and heat treating furnaces. You'll want a copy for your reference files, want to profit from its practical, authoritative information.
And remember as you read it, Hays engineers are thoroughly qualified and ready to work hand-in-hand with you in solving your own specific instrumentation and control problems . . . without obligation.
Write for your copy today . . . Ask for Bulletin No. 48-750 (covering heat-treating furnaces). Companion edition covering open-hearth furnaces will also be included.
Steel that's better, with more uniform grain structure . . . maximum production because of continuous equipment performance . . . fewer rejects . . . lower fuel, maintenance and labor costs—these are advantages you can count on when you use Hays instruments and controls for:
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NEW CITY ARISES NEAR CHILEAN STEEL PLANT

▲ A new city of more than 30,000 inhabitants will arise in southern Chile, when plans of the Compania de Acero del Pacifico reach completion.

The town, to be called Huachipato, will be built around the Huachipato steel plant now under construction in Concepcion Province, some 400 miles south of Santiago.

The Huachipato steel plant is scheduled to start production toward the end of 1950.

A pier already has been prepared at San Vicente, near the plant, for the unloading of raw materials and loading of the finished product.

At the end of January, said Desiderio Garcia, manager of the company, the metallic structure of the blast furnace will be erected. Near the furnace will be located a steam generating plant and an electric power plant with a capacity of 2,500 kilowatts for use in emergencies.

The foundations have already been laid for a plant for turning out by-products and the machinery will soon be installed. A rolling mill is also being set up.

FORD INAUGURATES MANAGEMENT TRAINING

▲ A management development program designed to offer new opportunities for employee advancement and management training has been inaugurated by the Ford Motor Co.

In announcing this, the company said the program, covering both salaried and hourly-rated employees would provide organized instruction in management responsibilities and added:

"It is the only way in which anyone can become a foreman or supervisor in the future. It is from the ranks of supervisors that future executives of the company will be selected."

Organized instruction will be through approximately 100 one-hour training sessions in such management responsibilities as personnel, quality standards, department operating costs, production, use of staff services, company development and effective use of tools, machines, equipment and materials.

McLOUTH POURS STEEL AT NEW FURNACE

▲ McLouth Steel Corp., Trenton, Mich., poured its first heat of steel in its new plant recently.

The first heat was made in a 60-ton electric furnace recently brought from Indiana Harbor and reassembled here. Initial production was about 50 tons, it has been learned. A second furnace, scheduled to go into operation during the next two weeks, also saw previous service at the Indiana Harbor plant of Youngstown Sheet and Tube Co.

McLouth has already erected a portion of its melt shop. Structural work is said to be progressing rapidly on that part of the building which will house two additional electric furnaces.

Meanwhile, construction work is proceeding for the pouring floor, blooming mill, soaking pits and run-out tables. When the plant is completed about May 15, it is expected to have a capacity of 36,000 tons per month.

10 BILLION TONS OF ORE AVAILABLE IN FRANCE

▲ More than ten billion tons of heretofore unusable iron ore in the Lorraine district of France can now be used for making iron in blast furnaces abroad, as a result of research studies completed here within the last six months. New equipment required to process the ore will cost from three to five million dollars per plant, and more than $100,000,000 will be required to equip blast furnaces in the Lorraine iron and steel plants alone, it was learned. Cost savings of 15 to 20 per cent in raw materials are envisioned under improved operations now possible.

These facts were determined recently when Herman A. Brassert, president of H. A. Brassert & Co., consulting engineers for the iron and steel industries, disclosed results of what he described as "the most important research discovery ever made" at the company's Washington, Conn., laboratories. His concern has been consultant to French government and private French steel interests during the past one and one-half years, when studies were made.

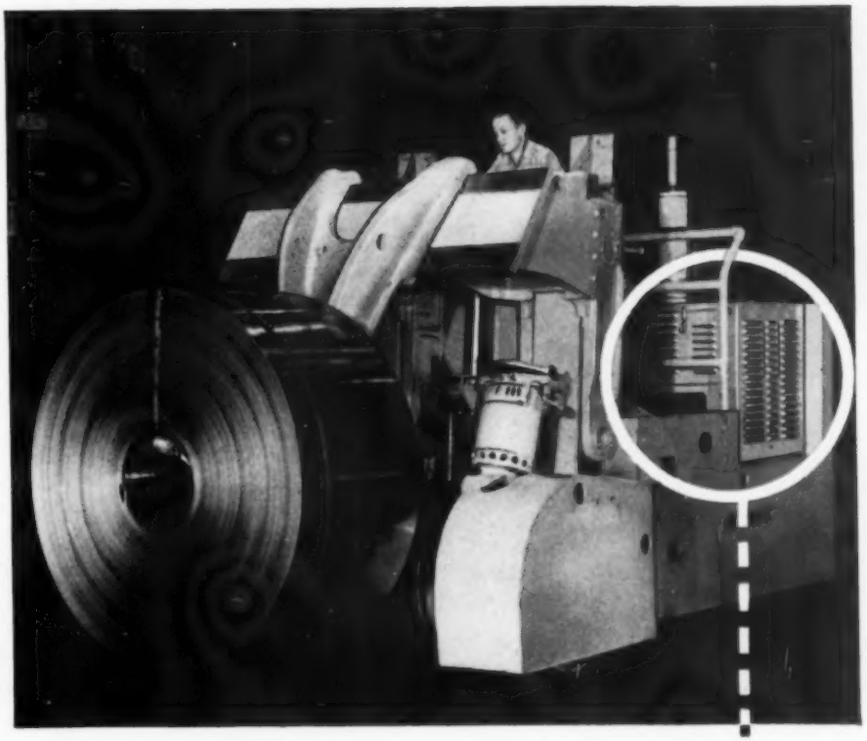
Describing conclusions of his research, he said immense reserves of

(*Please turn to page 136*)

constant power

FOR THE WORLD'S FASTEST STRIP MILL

Weirton Steel Works, Weirton, W. Va.



constant power

WITH READY-POWER-EQUIPPED ELECTRIC TRUCKS

Illustrated at top is one of two 2250 HP Motors at the Weirton Steel Works, Weirton, W.Va. furnishing *constant power* to drive the finishing rolls of the world's fastest cold-reduction strip mill capable of mile-a-minute production.

Equally constant and dependable is the power provided by the Ready-Power gas-electric unit on the "Automatic Skylift Giant" electric truck shown carrying one of the mill's 30,000 lb. rolls of finished strip. For electric trucks of any make or type, new or old, where constant power for hour-after-hour operation is needed—specify Ready-Power.

THE READY-POWER CO.

3836 Grand River Ave., Detroit 8, Michigan

Koppers *has what it takes*

to build good coke oven plants!

IT TAKES a good basic design.

We believe the Koppers-Becker Coke Ovens have the best of all designs . . . sturdy, free from complications, simple to control, with the largest practical coking capacity. This design can be used over a wide variety of conditions, making metallurgical or domestic coke with heating by any kind of fuel gas normally available, and in large or small sized ovens. The ovens are accessible throughout; this means low maintenance and long life.

IT TAKES constant engineering refinement.

The number of coke oven plants which Koppers builds gives this company an unparalleled opportunity to develop new ideas to meet the new needs.

For example, the waste gas recirculation system was developed by Koppers to meet the need for greater coal carbonization capacity per oven. To produce more coke from ovens, it became necessary to make them greater in height. To get uniform heat in walls of very high ovens, when heating with coke oven gas, it was necessary to delay the rate of combustion. This has been accomplished with the waste gas recirculation system.

IT TAKES a fine engineering staff.

Koppers engineering staff has proved its ability to design and erect the most advanced and efficient coal carbonization, material handling and gas treatment equipment.

KOPPERS COMPANY, INC.

Pittsburgh 19, Pa.

KOPPERS **ENGINEERING AND CONSTRUCTION DIVISION**

FASTER, SAFER

HOT METAL STAMPING

WITH Pannier "MASTER MARKER" SINGLE STROKE PNEUMATIC MARKERS

ANOTHER Pannier FIRST

Makes clean-cut, uniform stamping of hot metal products easy, fast and safe. Stamps ingot, heat and cut numbers or letters *at the same time.* Marks non-metals such as wood, fiber and plastic. Operates from any 80-100 pound air line. Automatic head trip assures clean impression, free from chatter marks. Long handle keeps operator at safe distance from hot work. Letters and figures quickly and easily changed. Available in several different styles with heads and interchangeable type made to your specifications. Tell us what you want to stamp; we'll recommend the right marker for your needs.

You saw these and other efficient Pannier Marking Devices at the Iron and Steel Exposition in 1948. Write for complete data on Pannier Single Stroke PNEUMATIC MARKERS.

OFFICES
Chicago, Ill. Los Angeles, Calif.
Youngstown, O. Philadelphia, Pa.

THE PANNIER CORPORATION
302 Pannier Bldg.
Pittsburgh 12, Pa.

FOREMEN STUDY BATTERY MAINTENANCE

John A. Kalasky, shop foreman, and Paul L. Jones, maintenance foreman, both of Eastern Gas & Fuel Associates replace a cell connector at one of the maintenance classes of the Gould Storage Battery Corporation's series of week-long schools on battery technology. At each session, maintenance representatives from user companies learn to care for and maintain storage batteries in their particular field — be it materials handling, underground haulage, standby power, railroad car lighting, air conditioning, etc. Students receive both theory and application training and copies of all lectures are given each student for ready reference back on the job.

(*Continued from page 133*)

siliceous (low-grade) ores in the Northern Minette District of Lorraine could be concentrated to a high degree—"52 per cent iron with iron recovery of 92 per cent."

WOLCOTT PREDICTS GOOD YEAR IN 1949

▲ Another year of high production and good business for Lukens Steel Co. was forecast by Robert W. Wolcott, president, in his annual report mailed recently to stockholders and employees of the company. This forecast is based on the existing backlog of orders at the close of the 1948 fiscal year and the present rate of entries for 1949 delivery of steel plate and steel plate specialties.

Unprecedented demand for steel plate specialties during the 1948 fiscal year brought a new high in sales of $61,460,919. The company also set a new record in the production of 647,876 net tons of ingots during the year, which is a result of the aggressive effort company management has put into manufacturing research and into all production methods and practices.

Under the company's program for 1949, approximately $2,500,000 will be authorized for expenditure, the largest portion of which will be used for the electrification of the 206-in. mill—"world's largest plate mill." This mill is now steam-operated.

CFI TOPS MILLION TONS IN 1948 SHIPMENTS

▲ A new high in steel shipped by Colorado Fuel & Iron Corp., was made last year with 1,069,809 net tons.

Despite these record production tonnages the Pueblo, Colo., plant experienced its best safety year. High spot of the year was a period when Pueblo put in 1½ million man hours without a lost time injury.

cilities were made. New equipment and production facilities were added at the rail mill in the form of new ingot handling equipment. In the open-hearth department archless door frames and water cooled doors as well as two new dolomite machines were added. Extensive modernization was done in the wire mill. A major new construction took place at the rod mill when on June 14 ground was broken for an entirely new mill. This mill, scheduled for completion early this year, will increase wire production of Colorado Fuel & Iron by at least 36 per cent.

FREYN AND OPEN HEARTH COMPANIES CONSOLIDATE

▲ Open Hearth Combustion Co. is now associated with Freyn Engineering Co. as a subsidiary. The two concerns will continue to function as independent units, but offices will be consolidated at the Freyn address. Open Hearth Combustion Co. will now offer complete services in design, construction and operation of steel producing facilities. The new officers of the Open Hearth Combustion Co. are as follows: George L. Danforth, Jr., chairman of the board; L. T. Shorley, president and treasurer; Harry Naismith, vice president; E. J. Wescott, secretary, and L. J. Kilboy, chief engineer.

PLANT HAS 258 DAYS WITHOUT ACCIDENTS

▲ More than a million work-hours without a major accident. That's a record that is still growing in Armco Steel Corp.'s fabricating division at Middletown, Ohio. C. E. Stutenroth, assistant manager of the division announced that the men of fabricating had worked a total of 1,030,000 consecutive hours without an accident that caused any of the 700 men to lose work.

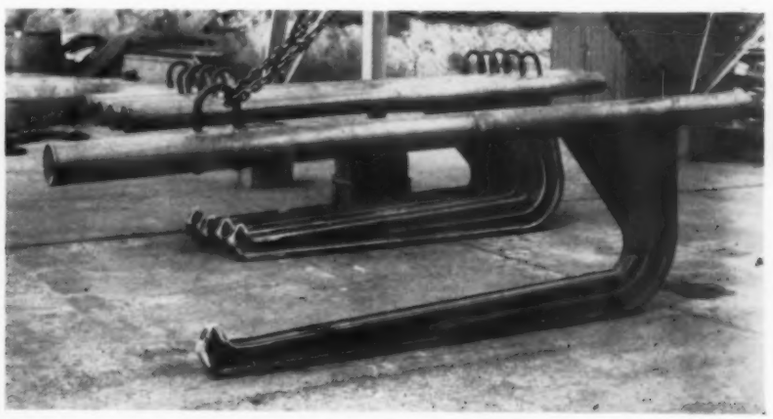
The 258 consecutive days of safety places the fabricating division in the lead in the National Safety Council's contest for heavy steel fabricators with a zero accident frequency rate (number of major accidents per million man hours).

The million-work-hours of safety earns for the Armco plant the distinguished service award of the National Safety Council.

117 YEARS OF SERVICE

On January 27th 2067 employees of the Mesta Machine Company received service pins indicating that they had been with Mesta for 10 years, 20 years, 30 years, and 40 years, or more. The family record is held by the four Weir brothers, whose combined service totals practically 117 years. Robert J. Weir (left), chief foundry schedule clerk, has been with Mesta for more than 39 years; William J. Weir (right), assistant auditor, 34 years; Walter T. Weir (center right), machine shop foreman, 30 years; and Frank T. Weir (center left), machinist, 14 years.

Hairpins THAT LIFT TWO TONS



WELDCO lightweight **hairpin hooks cut pickling costs . . . resist corrosion . . . last longer**

These hairpin pickling hooks, recently shipped to a leading Eastern wire mill, measure 14 feet in length, and each can handle 4200 pounds of coiled steel products at a time. Lightweight and unusually strong, the Weldco hooks are made of heavy, corrosion-resistant Monel plate. The spreader bars are of steel tubing, Monel-sheathed for maximum protection against strong pickling acids and fumes, and to keep scale or rust from falling onto the coil being processed.

Many wire mills throughout the country use Weldco hairpin hooks because of their excellent service record. Why not find out how these new, improved high-strength hooks can cut your costs? A phone call or letter will bring you complete information.

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3703 OAKWOOD AVE. . . . . YOUNGSTOWN, OHIO

Clean big parts with the OAKITE STEAM GUN!

HERE'S an easy way to clean metal parts that are too large to be soaked in tanks or conveyed through washing machines.

Just use the Oakite Solution-Lifting Steam Gun to apply an Oakite cleaning solution under about 40 pounds of steam pressure. Oil, grease and other dirts vanish quickly, leaving parts in perfect condition for further machining, overhaul or repair . . . The same gun may also be used with Oakite paint-stripping solutions.

FREE Write to Oakite Products, Inc., 19 Thames St., New York 6, N. Y., for illustrated folder F7338 containing more information about the various models of the Oakite Solution-Lifting Steam Gun and the many cleaning operations on which they are used with substantial savings in time and money.

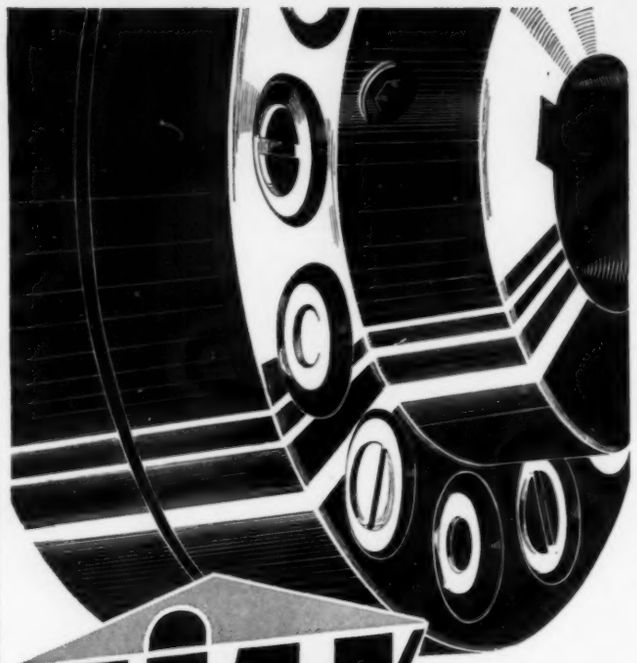
OAKITE 1909 1949 40th ANNIVERSARY YEAR

OAKITE

REG. U. S. PAT. OFF.

INDUSTRIAL CLEANING MATERIALS • METHODS • SERVICE

Technical Service Representatives Located in Principal Cities of United States and Canada

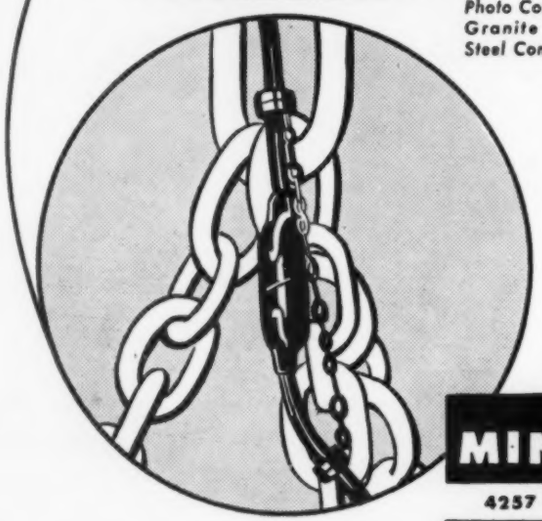


AJAX FLEXIBLE COUPLINGS

The fact that all the horsepower goes through the coupling emphasizes the importance of protecting direct-connected machines against misalignment.

AJAX FLEXIBLE COUPLING CO. INC., WESTFIELD, N. Y.

Photo Courtesy Granite City Steel Company



Insuring This GIANT'S GRIP...

caused grave concern at Granite City Steel Company, Granite City, Illinois plant until MINES Molded "Neoprene" rubber connectors were used to connect the magnet to its power cable (see illus.).

MINES Connectors were chosen because investigation proved them immune to conditions that caused other units to fail after short usage. 1st, MINES Connectors can't be accidentally disengaged. 2nd, MINES Connectors seal themselves against outside conditions when connected. This eliminates current creepage due to moisture or dirt infiltration between contacts. 3rd, Pins amd sockets in MINES Connectors are designed to maintain positive full length contact under vibration. 4th, Molded as one piece Neoprene rubber units, MINES Connectors won't crack or shatter under hard impact. Their tapered neck design provides extra strength at the vital cable connector junction and prevents dangerous wire fraying or breaks.

MINES Neoprene rubber Connectors will solve your magnet connector problems too. For a quotation give us the size and electrical characteristics of your magnets.

MANUFACTURED BY

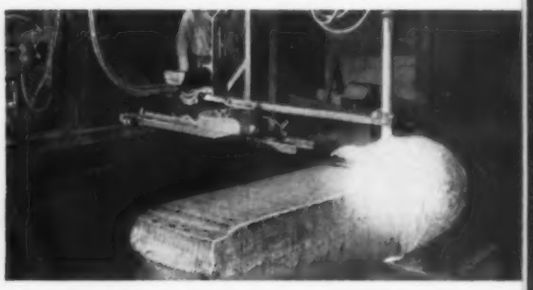
MINES EQUIPMENT COMPANY

4257 CLAYTON AVE. MINES **ST. LOUIS 10, MO.**

At the blast furnaces and open hearths, oxygen plays an important part. Furnace-tapping with the oxygen lance—oldest use of oxygen-cutting in steel plants—still saves time and reduces hazards.

Help on the Hot and Heavy Jobs

Ingots requiring 200 hours for mechanical "parting" have been split with the OXWELD C-45 heavy-duty blowpipe and then machined in 14 hours total time.



Cutting the hot top off this 26-inch forged slab with the C-45 blowpipe took less than 10 minutes and left the slab end square and undeformed.

The deseaming blowpipe, equipped with the OXWELD starting-rod feed, has reduced conditioning costs more than 50 per cent.

Draining furnace salamanders by oxygen-lance tapping has reduced furnace down-time more than three weeks in some steel plants.

LINDE service engineers who co-operate closely with the steel industry—have combined experience, knowledge, and practical "know-how" to help make better steel, faster, and at lower cost.

LINDE engineering service is always available to LINDE customers through the nearest LINDE office.

Linde

The words "Linde" and "Oxweld" are registered trade-marks of Units of Union Carbide and Carbon Corporation.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

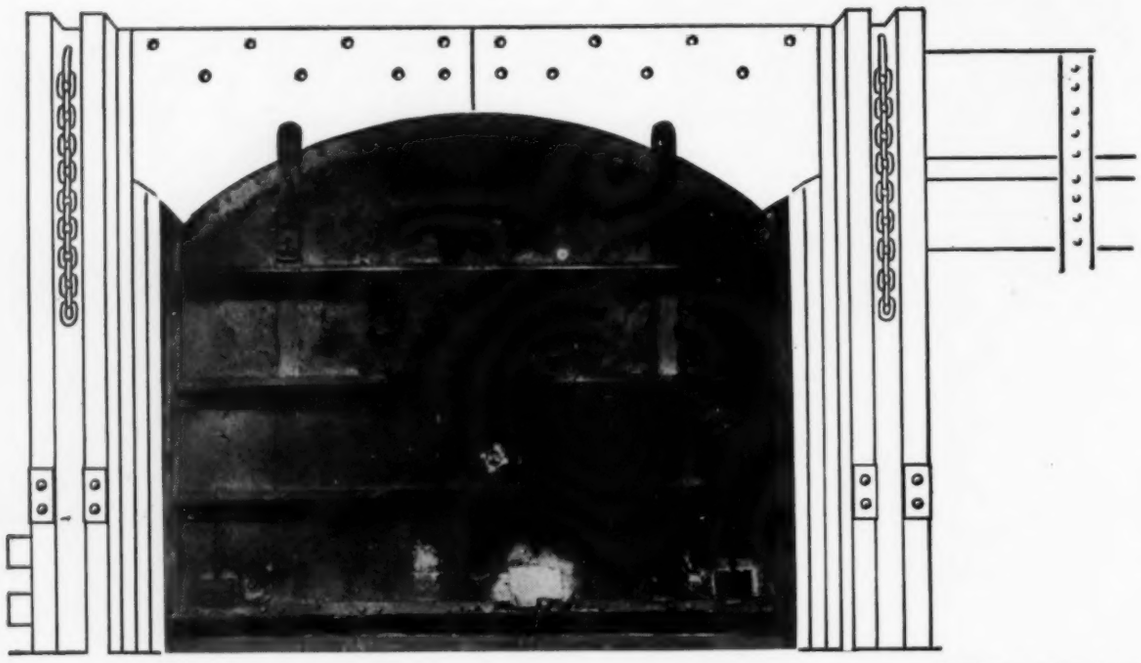
30 East 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

Annealing Furnace Door and Car Top

easier, more economical to build . . . more serviceable

with LUMNITE REFRACTORY CONCRETE



Exterior of door linings on Annealing Furnace, built with Refractory Insulating Concrete.

CONSTRUCTION: This big furnace door was cast in the metal door frame. Refractory Insulating Concrete, made with *"LUMNITE" cement and crushed insulating firebrick grog, was placed in the forms. Within 24 hours after placing the door was ready for service.

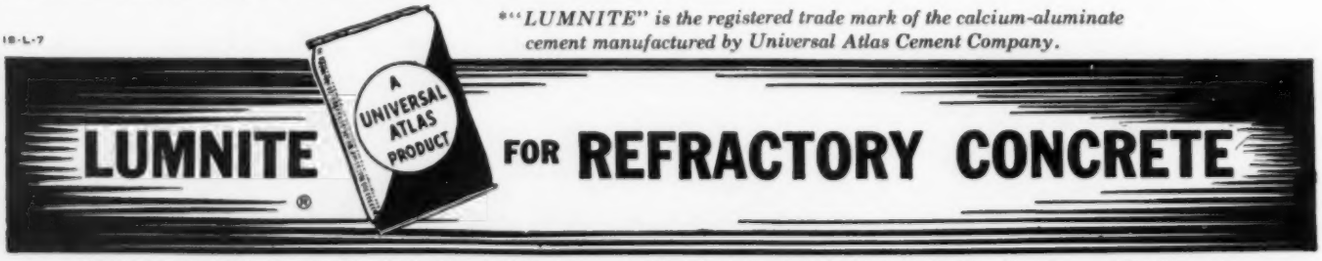
SERVICE: Operating costs are reduced. With its monolithic, one-piece construction, there are no small units to work loose and weaken the installation. Absence of joints and the exceptional insulating properties of Refractory Concrete reduce heat loss and infiltration of cold air. Repeated heating and cooling of the furnace does not cause the Refractory Concrete to deteriorate, because it is exceptionally resistant to spalling and other effects of furnace temperatures. Thus furnace efficiency is kept at a high peak and maintenance expense remains low.

Send for detailed information on methods of using Refractory Concrete in annealing furnaces. Write to LUMNITE DIVISION, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), Chrysler Building, New York 17, New York.

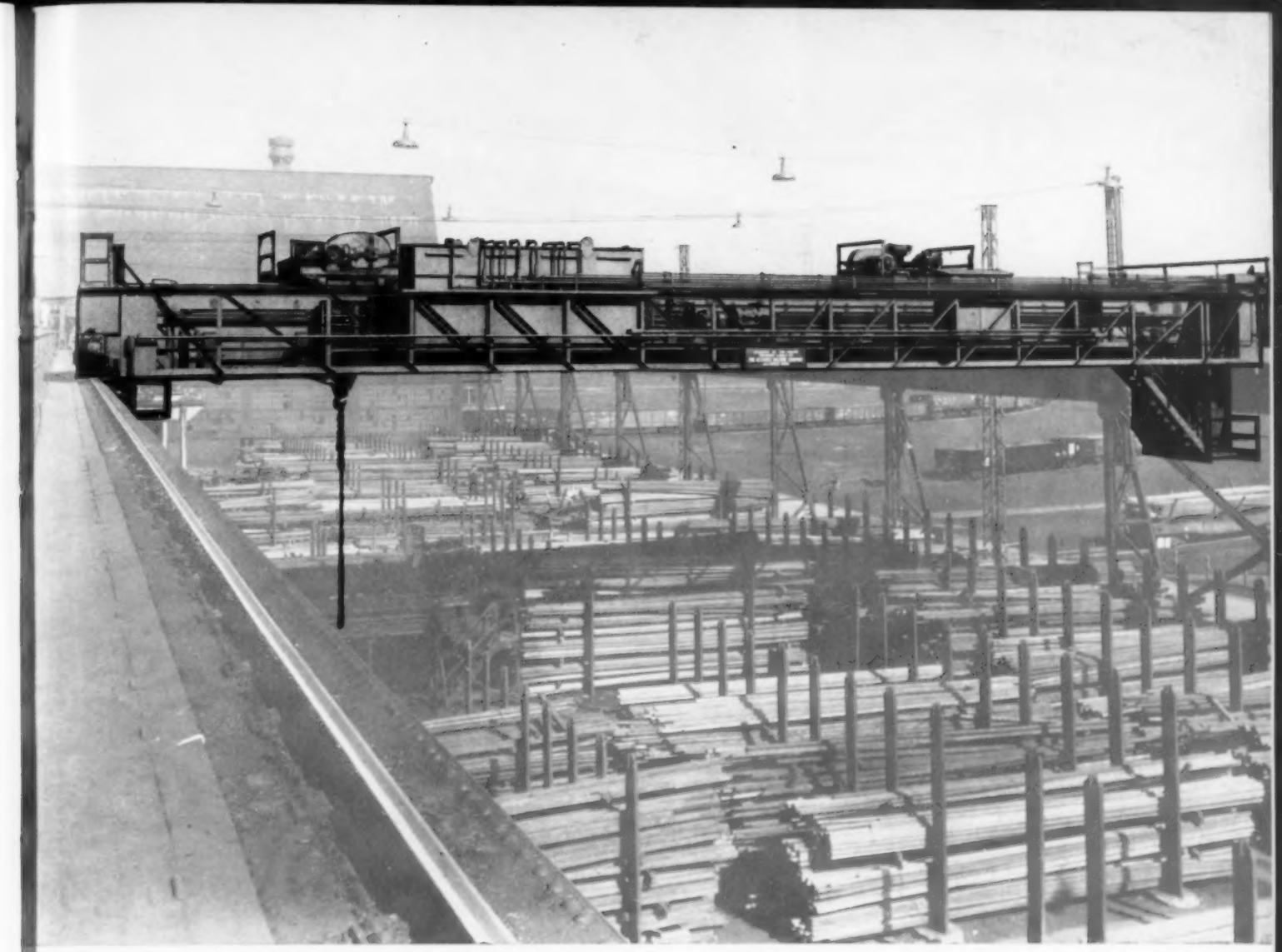
FURNACE CAR TOP of Refractory Concrete was cast in place in simple side forms. Monolithic construction with Refractory Concrete, made with LUMNITE calcium-aluminate cement and crushed firebrick, permits easy setting of heavy forgings, castings or annealing boxes. No small units to tear out and leave ragged, rough surfaces. No joints to fill with scale and dirt. Highly resistant to spalling.

"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

18-L-7



"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—ABC Network*



Alliance KEEPS HEAVY INDUSTRY ON THE MOVE

Wherever production schedules must be maintained hour after hour—24 hours a day—week after week—you'll find rugged, dependable Alliance equipment on the job. Alliance cranes—like the 15-ton double trolley, 102-foot span yard crane shown above—keep heavy industry on the move day in, day out, because they're built for long, continuous service . . . to help plants maintain smooth-flowing production schedules at less operating cost.

Alliance engineering specialists have designed and developed thousands of cranes to handle all types of loads . . . quickly, safely, and easily . . . in many different industries. Let Alliance—World's Largest Builder of the World's Largest Cranes—develop the equipment best suited to your company's material handling operations.

MAIN OFFICE — PITTSBURGH OFFICE

THE ALLIANCE MACHINE COMPANY · ALLIANCE, OHIO · 1622 OLIVER BLDG., PITTSBURGH, P.

Consult Alliance on

LADLE CRANES · GANTRY CRANES · FORGING MANIPULATORS
SOAKING PIT CRANES · STRIPPER CRANES · SLAB AND BILLET
CHARGING MACHINES · OPEN HEARTH CHARGING MACHINES
SPECIAL MILL MACHINERY · STRUCTURAL FABRICATION

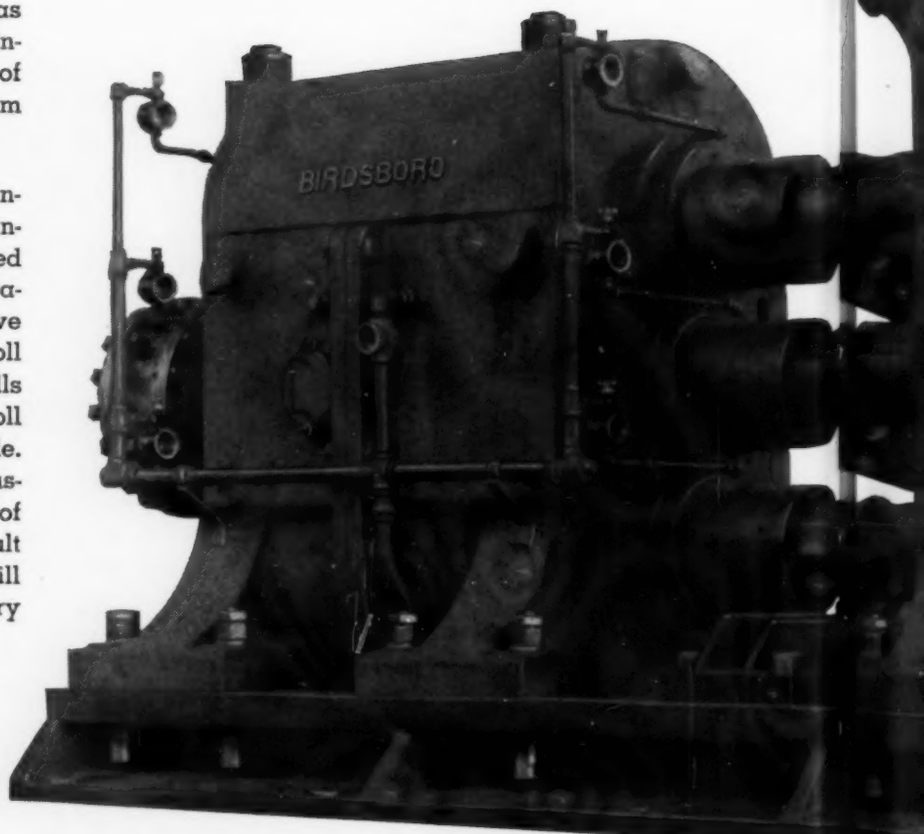
Alliance

Reduce STOP and GO ROLLING

Keep Pr

If you are looking for long, uninterrupted service in steel mill equipment, put the job up to a Birdsboro Rolling Mill like the one shown here. This is a 20" 3-high bar mill that has been soundly designed and engineered to produce greater tonnages of accurately rolled shapes at minimum operating and maintenance costs.

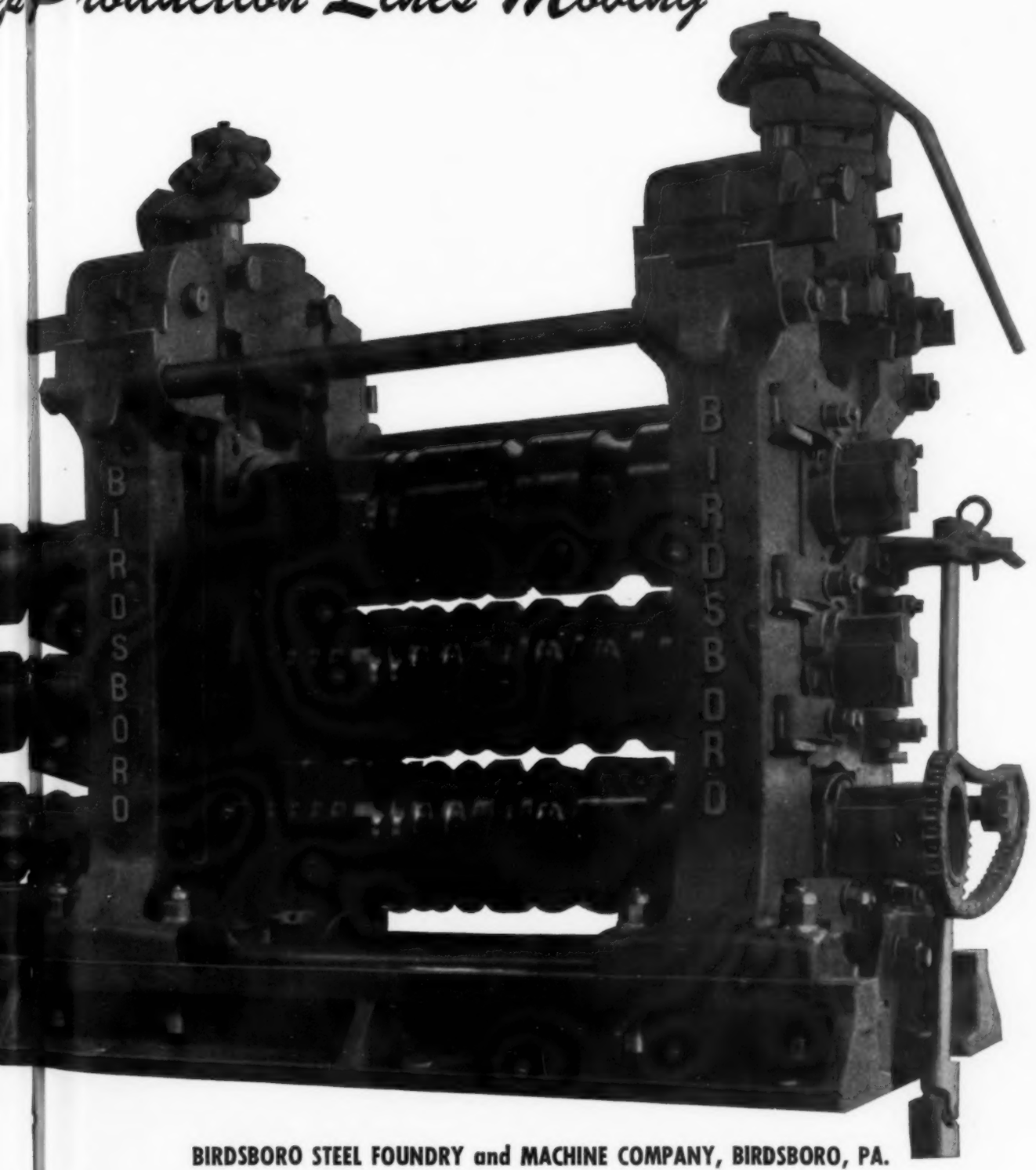
This mill is rugged, all-steel construction and its up-to-date design incorporates many features that speed production and simplify its operation. The open top roll housings have housing caps designed for quick roll changes. The top and bottom rolls are easily adjustable. The feed roll is chain driven on the entering side. And the totally enclosed pinion housing has forced feed lubrication of pinion teeth and bearings. Consult Birdsboro when you have any mill equipment or special machinery problem.



BIRDSBORO
STEEL MILL EQUIPMENT

DESIGNERS and BUILDERS of: Steel Mill Equipment • Hydraulic Presses • Rolls
Special Machinery • Crushing Machinery • Steel Castings

Production Lines Moving



BIRDSBORO STEEL FOUNDRY and MACHINE COMPANY, BIRDSBORO, PA.

OFFICES IN: Birdsboro, Pa. and Pittsburgh, Pa.

REPRESENTATIVES AT: 332 South Michigan Ave. Chicago 4, Illinois — 507 Terminal Tower Bldg. Cleveland 13, Ohio

USE CARBON!

Sales of "National" carbon mold plugs jumped nearly 50% in 1948 because:

1 With "National" carbon mold plugs, there is no contamination of ingot.

2 Carbon plugs will not stick to the ingot. They may be used more than once.

3 Carbon plugs are light, yet strong, so handle easily.

4 Carbon mold plugs are consistently accurate in dimensions.

5 Carbon's resistance to thermal shock and hot-metal erosion increases service life.

For more information, write to National Carbon Company, Inc., Dept. IS

These products sold in Canada by
Canadian National Carbon Company Limited, Toronto 4, Canada

The term "National" is a registered trade-mark of
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.
Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
Foreign Department: New York, U. S. A.

Personnel News...

M. W. Reed was named vice president-engineering of U. S. Steel Corp., Pittsburgh, Pa., to succeed **B. H. Lawrence,** who is retiring after over forty-four years of service with United States Steel. Mr. Reed has served with subsidiaries of United States Steel continuously since 1916 and has been chief engineer, United States Steel Corp. since January 1, 1948. A native of Lexington, Mass., Mr. Reed attended public schools there and was graduated in 1916 from the U. S. Naval Academy with a B.S. degree. Later that year he began work as a wire tester at the north works of American Steel & Wire Co. in Worcester, Mass. He advanced through various positions at both the North and South works in Worcester, and at the New Haven, Conn. plant of the same company, to the position of superintendent of New Haven works, which he held from 1925 to 1928. He became assistant district manager at Worcester in 1928 and four years later was promoted to chief engineer of American Steel & Wire, at Cleveland. He became operations vice president of the company in 1937 and in 1939 was appointed chief engineer of Carnegie-Illinois Steel Corp., with headquarters in Pittsburgh. In April 1947 he became vice president-engineering of Carnegie-Illinois, holding that position until his appointment as chief engineer of United States Steel Corp. of Delaware a year ago.

H. D. Stark, assistant to the vice president in charge of operations, Jones & Laughlin Steel Corp., Pittsburgh, Pa., has retired. Mr. Stark has completed 49 years of service with J&L. He started at the age of 16 as a draftsman in the engineering department of Pittsburgh works. After serving as superintendent of the machine shop, the steel works, and the blooming mill departments, he was appointed assistant general superintendent of Pittsburgh works in 1927. He served as general superintendent from 1936 until August, 1947, when he was appointed assistant to the vice president, operations.

E. K. Miller, formerly assistant to the vice president-operations, has been appointed assistant vice president-operations for Jones & Laughlin Steel Corp., Pittsburgh, Pa. Mr. Miller joined Jones & Laughlin Steel Corp., Aliquippa works, in 1929 as superintendent of steel works, and later was promoted to the positions of assistant general superintendent and general superintendent of the Aliquippa works.

R. M. Hussey, formerly superintendent of Jones & Laughlin Steel Corp., Aliquippa works rod and wire department, was appointed assistant manager of construction. Mr. Hussey has been with J&L since 1915. He served as superintendent of the electrical department, Aliquippa works, from 1920 until 1930, when he was appointed superintendent of the rod and wire department.

N. A. Hansen, formerly assistant superintendent of Jones & Laughlin Steel Corp., Aliquippa works rod and wire department, has been appointed superintendent of that department. He was first employed by J&L in 1926 and has been with the rod and wire department since 1929.

F. D. Wilkins, formerly general foreman of the rod and wire department, Aliquippa works, of Jones & Laughlin Steel Corp., has been appointed assistant superintendent of the department. Mr. Wilkins joined the Aliquippa works in 1927 and served in various positions until he was appointed general foreman of the rod and wire department in 1946.

F. A. Campbell, formerly liaison engineer on the chief engineer's staff, was appointed superintendent of field construction for Jones & Laughlin Steel Corp. Mr. Campbell has many years of experience with J&L in the field of construction. He served as construction engineer and superintendent of construction, Aliquippa works, from 1925 until he was appointed liaison engineer last September.

Gilbert G. Galambus was named superintendent of the roll department at the Indiana Harbor plant of Youngstown Sheet and Tube Co. Mr. Galambus began his apprenticeship as a roll turner at the age of 17 with Carnegie-Illinois Steel Corp. at Gary. He joined Youngstown Sheet and Tube Co. in 1929 as a draftsman in the roll department, became a roll designer in 1935 and was appointed assistant superintendent of the department four years later.

C. A. Scharschu, director of research of Allegheny Ludlum Steel Corp., Pittsburgh, Pa., has been ap-

M. W. REED

H. D. STARK

E. K. MILLER

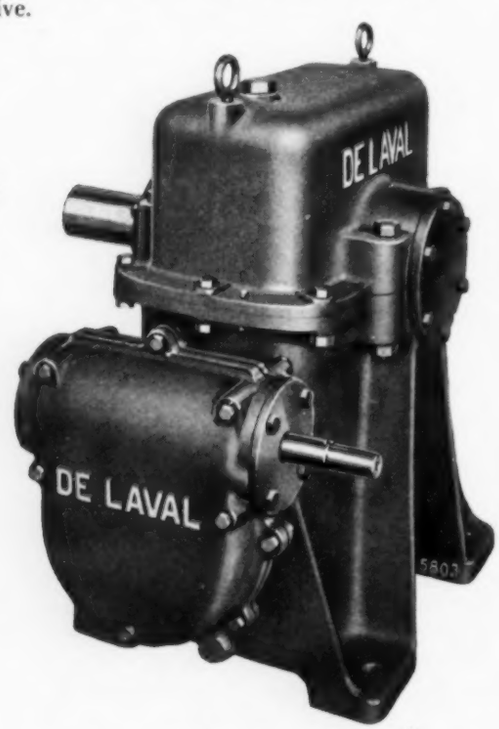
R. M. HUSSEY

HIGH TORQUES?

DE LAVAL SPEED REDUCERS

For low final speeds Worm Gear Speed Reducers should be selected on the basis of output torque ratings.

If your problem is to select a gear reducer capable of carrying high torques, consult De Laval, either directly or through a sales representative.



ONE OF 93

This double reduction De Laval Worm Gear Speed Reducer is available with many standard gear ratios and is but one of 93 sizes and types of standard De Laval Worm Gear Speed Reducers.

Worm Gear Division

DE LAVAL WG-11

De Laval Steam Turbine Co., Trenton 2, N. J.

TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS
CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

pointed assistant technical director. **Dr. L. C. Hicks,** associate director of research, will fill Mr. Scharschu's former position.

H. H. Morgan, formerly roll designer, has been appointed assistant roll engineer for Jones & Laughlin

H. H. MORGAN

Steel Corp. Mr. Morgan has been with J&L since August, 1945. He came to the corporation from the iron and steel division of Kaiser Co., Inc.

George H. Schaeffer has entered the field of consulting engineering. Mr. Schaeffer's headquarters will be at 1427 Perkiomen Ave., Reading, Pa. Mr. Schaeffer, a past president of the Association of Iron and Steel Engineers for the year 1926, was graduated from Lehigh University in electrical engineering. He started his steel mill career in 1908 as electrical engineer at Carpenter Steel Co., where he became acquainted with electric

GEORGE H. SCHAEFFER

furnaces for both the arc and high frequency types for melting and the various types for annealing, including bright annealing with controlled atmospheres. He has served on a number of national committees of the Association, and is still a member of the advisory committee. His consulting engineering work will specialize in industrial and municipal work covering all phases of electric power and heating and process applications.

Robert E. Mauger has been appointed assistant of the pipe mill at the Indiana Harbor works of Youngstown

Sheet and Tube Co. Mr. Mauger was formerly electrical division foreman for the tube and skelp mills.

George H. Sahler has been appointed manager of marketing research of the Trumbull Electric Manufacturing Company at Plainville, Connecticut. Mr. Sahler was employed in the purchasing department of E. I. duPont before he entered the service in 1943. A native of Joliet, Illinois, Mr. Sahler attended Joliet Junior College and graduated from the University of Chicago's School of Business with a bachelor of arts degree.

T. C. Glenn was appointed manager of the engineering division of General Electric Co.'s newly-created Michigan district. Mr. Glenn, who assumed his duties January 1, 1949, will be in charge of all application and service engineering work in the district as well as all types of installation contracts. In addition, he will be in charge of, and responsible for, all the Michigan district service shops.

Maynard B. Terry has been appointed vice president of the American Brakeblok division of American Brake

MAYNARD B. TERRY

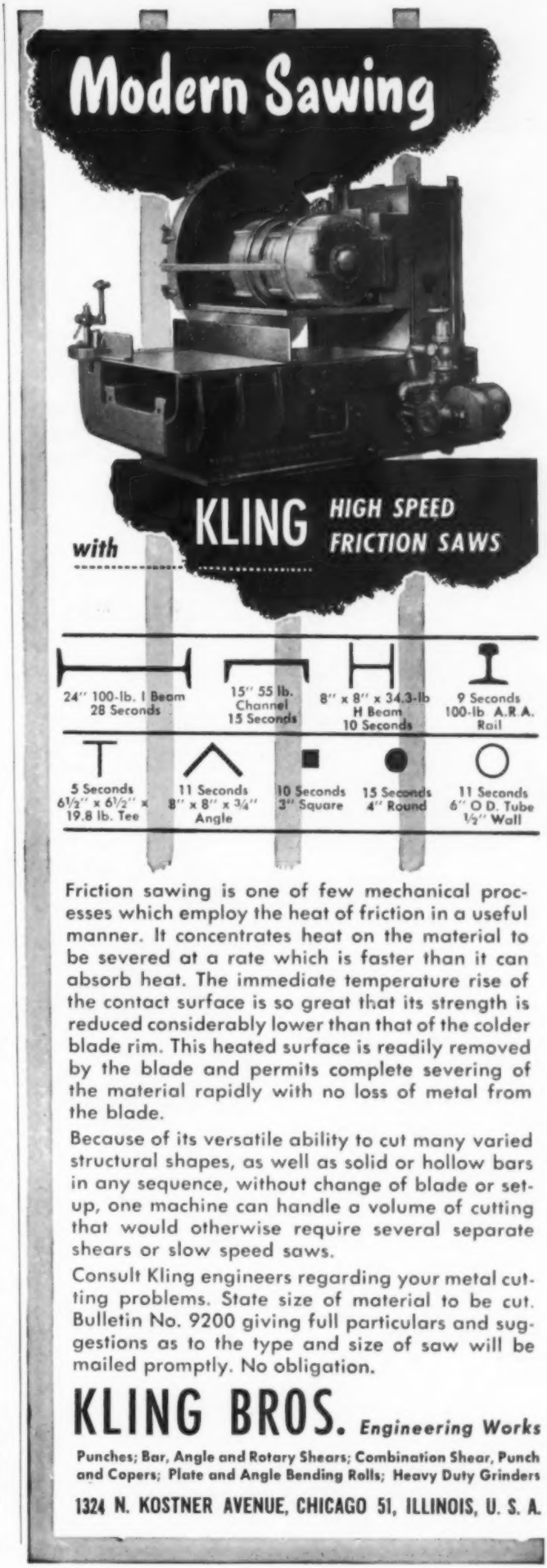
Shoe Co. Mr. Terry, formerly general sales manager, has served in various sales capacities since joining American Brake Shoe Co. in 1943.

Ernest G. Unrath was named general superintendent at Spang-Chalfant division of National Supply Co., Ambridge, Pa. He succeeds H. J. Litsey who died in September, 1948. Mr. Unrath has been superintendent of the hot mill since 1945.

F. W. Chambers, who returned recently after a year and a half in Chile, working on a steel mill project for which Koppers Co., Inc., is consultant, has been named manager of production for Koppers engineering and construction division. **O. H. Chambers** was appointed assistant manager of production. A third appointment announced was that of **A. B. Fisher, Jr.,** a production engineer, as chief engineer of the division. Mr. Fisher succeeds **Ragnar Berg,** who will become consulting engineer for the division. Mr. Berg's future duties will be largely in connection with the expanding foreign activities of the division.

Norman Rendleman, roll engineer, has been added to the staff of the United Engineering & Foundry Co. as a special consultant. Mr. Rendleman brings to United over 40 years of experience with the Jones & Laughlin Steel Corp.

Henry W. Johnson is retiring as vice president in


Modern Sawing
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KLING HIGH SPEED FRICTION SAWS
24" 100-lb. I Beam 28 Seconds
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9 Seconds 100-lb A.R.A. Rail
5 Seconds 6½" x 6½" x 19.8 lb. Tee
11 Seconds 8" x 8" x ¾" Angle
10 Seconds 3" Square
15 Seconds 4" Round
11 Seconds 6" O.D. Tube ½" Wall

Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Consult Kling engineers regarding your metal cutting problems. State size of material to be cut. Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

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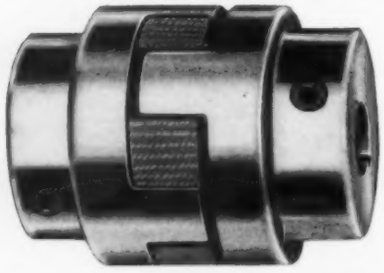

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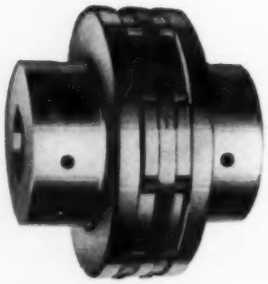

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charge of manufacturing for De Laval Steam Turbine Co., but will continue as director and a member of the executive committee. **C. Richard Waller** has been named vice president and director for engineering. **H. G. Bauer** has been elected vice president and executive vice president and executive engineer. **J. P. Stewart**, commercial sales division, has been elected a vice president. **W. A. Reynolds** assumes responsibility for the development and merchandising of new small products in addition to his position as manager of the present IMO pump and worm gear divisions.

R. G. Adair was appointed director of personal rela-

R. G. ADAIR

HUGH W. WRIGHT

tions and **Hugh W. Wright** was named director of public relations for Armco Steel Corp., Middletown, Ohio.

L. J. Suelzer has been appointed manager of the newly created Bowser, Inc., Pittsburgh district office with headquarters at 502 Oliver Building, Pittsburgh, Pa., and **T. R. Schannen** has assumed Mr. Suelzer's former position as manager of the lubrication and filtration sales division at the home office in Fort Wayne, Ind. **C. P. Menard**, with Bowser, Inc., since 1924, has been lubrication and filtration engineer stationed in Pittsburgh since 1937. In his new duties he will be sales engineer reporting to Mr. Suelzer.

W. Van C. Brant has been appointed manager of the newly-formed railway and motive power sales division of Electric Storage Battery Co. Mr. Brandt previously had been manager of motive power battery sales.

Walter A. Jayme was appointed general superintendent of the Gary works of National Tube Co. Mr.

WALTER A. JAYME

Jayme has been assistant general superintendent of the plant since 1947. No successor to the assistant's post has been appointed.

J. A. Robinson was appointed sales manager for the Transporter division of Automatic Transportation Co. Mr. Robinson, whose background includes 25 years in advertising, comes to Automatic from Ruthrauff & Ryan, Inc., Chicago, the agency which handles Automatic's account.

C. Hubert Lenhart has resigned his position as general superintendent of Kaiser Co., Inc., Fontana, Calif., to associate himself as a vice president of H. A. Brassert & Co., New York, N. Y.

E. L. O'Meara, Jr., was promoted to assistant chief engineer of Harbison-Walker Refractories Co. Mr. O'Meara has been chief draftsman of the construction division since 1935.

William N. Bartleson was named superintendent of the Harbison-Walker Refractories Co. at Chester, Pa. He has been assistant superintendent since 1942.

John V. Boardman, formerly assistant general manager of Worth Steel Co., Claymont, Del., has been appointed general superintendent. Before joining the Worth Steel Co. in June, 1946, he was connected with

JOHN V. BOARDMAN

the rolling mill department at Jones & Laughlin Steel Corp., Pittsburgh works, Pittsburgh, Pa.

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NON-FLUID OIL stays where it's put until entirely used up and does not drain away from bearings when machinery is stopped.

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John E. N. Hume, commercial vice president, General Electric Company, Schenectady, New York, has retired after 41 years of service. Mr. Hume joined General Electric in 1907 and became associated with the switchboard engineering department. For a time he was at the Baltimore office as salesman and later returned to Schenectady in the industrial department. He later became manager of sales of the mining and steel mill section. He was successively manager of the motor division, assistant manager, and then manager of the industrial department and was elected a commercial vice president in 1938.

William I. Ong was appointed assistant to the president of American Steel & Wire Co., Cleveland, Ohio. Mr. Ong has directed the company's public relations department since its organization in May, 1937, and the Ohio-Michigan district public relations activity of other U. S. Steel subsidiaries as well. Prior to 1937, he was associated for 10 years with Dow-Jones & Co., pub-

WILLIAM I. ONG

lishers of the Wall Street Journal. Mr. Ong was born in Columbus, Ohio, on May 14, 1906. As a boy, he moved to near-by London, Ohio, where he attended school. He was graduated from DePauw University with a B.A. degree in 1928, and immediately went to work as a financial writer for Dow-Jones in New York. A year later, he was transferred to Cleveland as manager of the company's office.

Raymond E. Tibbetts was named division superintendent of the spring mill and rail bond division of American Steel & Wire Co., South works, Worcester, Mass. Mr. Tibbetts has been customer contact representative in that division.

Harold J. Elmendorf was made chief spring engineer, American Steel & Wire Co., South works, Worcester, Mass. Mr. Elmendorf since February, 1948, has been division metallurgist at the spring mill.

Erick R. Karlson was appointed division supervisor, production planning, spring mill and rail bond division, American Steel & Wire Co., South works, Worcester, Mass. Mr. Karlson has been planning engineer.

John W. Bates has been appointed general superintendent of the integrated steel plant now under construction by Compania de Acero del Pacifico in Chile, South America, and being projected in the offices of Corporacion de Fomento, 37 Wall St., New York, N. Y. Mr. Bates, who was formerly serving as project manager, left for Concepcion, Chile on December 23, 1948.

Fred H. Ruff has been appointed controller of the new steel plant of the Compania de Acero del Pacifico now being erected at Concepcion, Chile. He was formerly secretary and treasurer of the Jessop Steel Co., Washington, Pa. Mr. Ruff will be located at the New York office of the Corporacion de Fomento de la Produccion of Chile and will leave the United States early in the spring. Partial operation of the new plant of the Compania de Acero del Pacifico is scheduled to begin in August, 1949. Mr. Ruff joined the Jessop Steel Co. as controller in 1944. Previously he was employed by the Universal-Cyclops Steel Corp., Bridgeville, Pa., and by the Jones & Laughlin Steel Corp., Pittsburgh, Pa.

Willis B. Clemmitt has been elected vice president of Freyn Engineering Co., Chicago, Ill. Mr. Clemmitt has been associated with the company since 1923 and has served a considerable period of years as chief engineer.

Robert G. Allen, of Cohasset, Mass., has been elected vice president in charge of the Great Lakes Carbon Corp.'s electrode division. Mr. Allen, formerly manager of the division, continues to make his headquarters at the Niagara Falls plant.

Arthur B. Dreissiger was elected vice president and manager of operations and **Bernard H. Niehaus, Sr.** was named treasurer-comptroller of Factory Stores. Factory Stores now handle in-plant food service at 60 plants distributed over seven states.

Obituaries

Frank C. Jones, president and general manager of Okonite Co., Passaic, N. J., died January 20, 1949, at the Lenox Hill Hospital, New York City, following a three-months' illness. A graduate of Nobel and Greenough School, Boston, Mass., and a member of the Class of 1910 at Harvard University, Mr. Jones started his business career with B. T. Babbitt, Inc., and later was treasurer of Edgar A. Wilhelmi, Inc., export agents. In 1914 he established an importing business, Jones and Cammack, which he left in 1917 to serve in the Army Ordnance Department during World War I, later becoming a captain. Following the death of his father, one of the founders of Okonite Co., he became a director of Okonite, and in 1919 was elected treasurer and general manager. He was elected president and general manager in 1932. He was also president of The Okonite-Callender Cable Co., Inc., of Paterson, N. J.

J. H. Morrison, 56, vice president and director of Pittsburgh Steel Co., Monessen, Pa., died January 18 at the Youngstown Hospital. Mr. Morrison had an extensive industrial career, entering the steel industry in 1915 with the Youngstown Iron and Steel Co., which was later absorbed by Sharon Steel. He advanced through the organization, becoming superintendent of the rolling mills at Sharon and Lowellville, Ohio plants of the corporation. Mr. Morrison joined Pittsburgh Steel Co. in 1936 as superintendent of the blooming, bar and billet mills, and subsequently became superintendent of the hot mills of both the Monessen and Allenport plants. In 1940 Mr. Morrison returned to Sharon Steel Corp. as general works manager, and later became vice president in charge of operations.

In October, 1945 he returned to Pittsburgh Steel Co. as general works manager, and in 1946 was elected vice president in charge of operations and a director.

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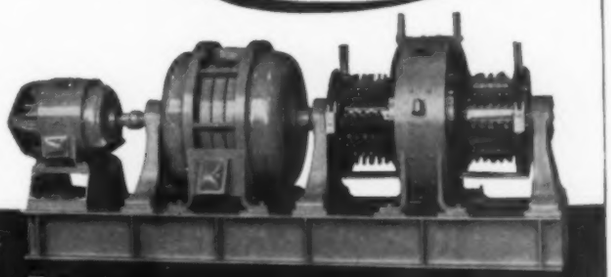

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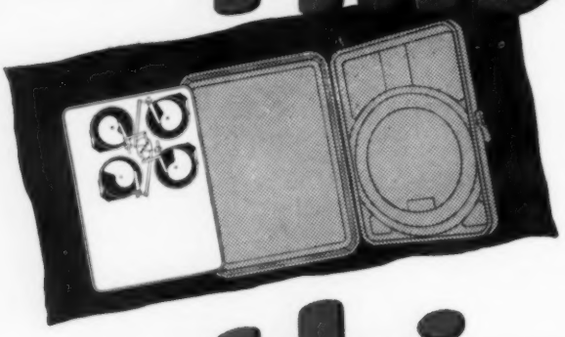

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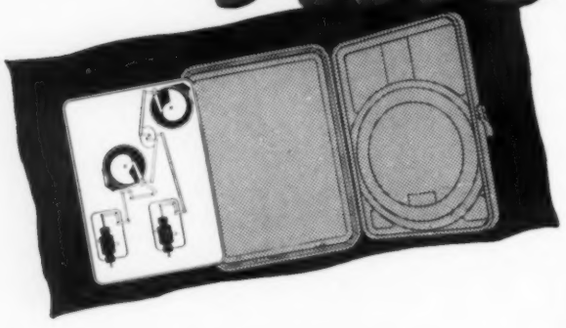

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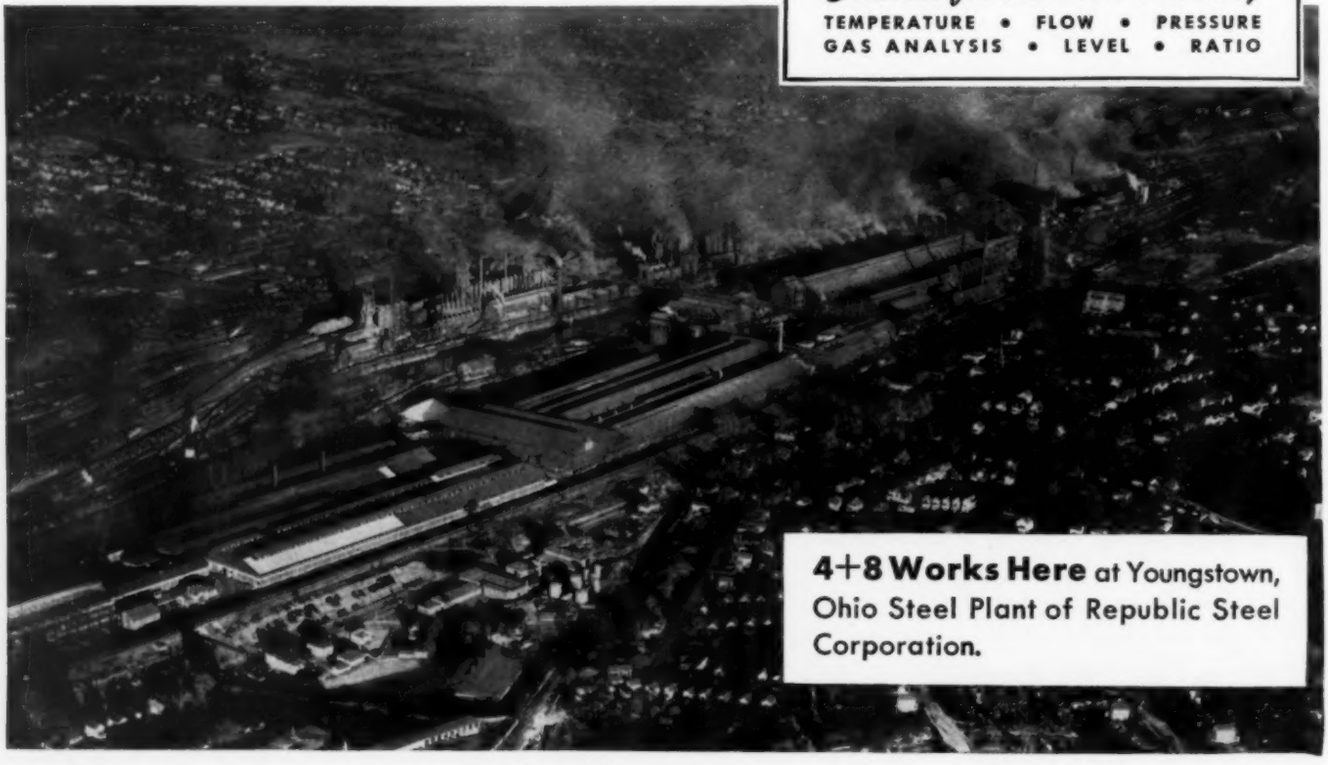

4+8 Works Here at Youngstown, Ohio Steel Plant of Republic Steel Corporation.

Publication Service...

(1) pH and Conductivity Control

pH and conductivity control and their application to different industrial processes is a feature of the new catalog just published. Typical examples presented include pH control in heavy industries. The Catalog also offers a discussion of the fundamentals of pH, oxidation-reduction potential and conductivity and describes various instruments such as the ElectroniK potentiometer, flow electrode assembly, the Beckman pH Amplifier, as well as electrodes, conductivity cells, control valves, motors and pneumatic control accessories. Fully illustrated with photographs and schematic drawings, "pH and Conductivity" includes in its 43 pages a partial list of circular and strip charts and scales and dimensional diagrams of pH equipment. (15-12). Brown Instrument Co.

(2) Magnetic Pulleys

A complete description of features and applications of electromagnetic pulleys and "Alnico Magnetic Perma-Pulleys" for automatic separation of ferrous and non-ferrous materials is given in two new eight page catalogs recently issued. Catalog C-1001A describes the purpose, operation principle and advantages of Dings electromagnetic pulleys, including the design features of air-cooled pulleys, solid type pulleys and waterproof, greaseproof or heatproof special pulleys. Actual installations of the electromagnetic pulleys are illustrated and the many possible applications in a wide variety of industries are described in detail. Catalog C-1007A details the features of the newly developed "Perma-Pulley." Design features described include the advanced spoke design which permits use of the greatest amount of Alnico in the space available; closely spaced poles; non-magnetic gap plates and light metal heads; crowned face; and other new features. The operating principle is explained in detail, and the wide variety of practical applications is amply illustrated. Dings Magnetic Separator Co.

(3) Rotating Regulator

A new 22-page booklet is announced which tells the story of the rotating regulator "Rototrol" in the steel industry; its functions, its applications, and its outstanding accomplishments as a control for steel producing machinery. In the pages of the new booklet the reader will learn how Rototrol has been applied to virtually every phase of steel production from speed regulation for skip hoist drives to tension control for strip winding . . . and how its application to these operations has led to marked improvements in the finished product and in the speed and economy of its production. The booklet points out how this regulator has met the need for a simple reliable regulator, which is capable of withstanding the rigors of steel mill usage and which is sufficiently elemental in operation so that it can be understood by non-technical maintenance personnel. (A-49044). Westinghouse Electric Corp.

(4) Rotary Positive Blowers

Just issued is a completely new booklet on rotary positive blowers. This 20-page bulletin discusses operating advantages and principles, and is accompanied by several performance curves under various operating conditions. Separate pages are devoted to the four standard types of blowers, showing complete views and cross-sections of each, with condensed specifications. A section is devoted to a discussion of gears, which are cut to insure the required accuracy. Another section discusses the various types of accessories recommended, including relief valves. (22-23-B13). Roots-Connersville Blower Corp.

(5) Wire and Cable Catalog

A 48-page illustrated wire and cable catalog has been announced. In the new catalog are listed thermoplastic, braided and leaded building wires, BX cable, entrance cable, braid X and PVX cables, as well as the complete line of "Flamenol," neoprene, rubber, and braided cords and portables. Included, too, are Type C cord and the new shot-firing cords which have just been added to the company's line. In addition, valuable information on National Code requirements is given and many of the NEC tables most commonly referred to are printed in their entirety. Appliance and Merchandise Department, General Electric Co.

(6) Thermocouple Manual

A complete new thermocouple manual has been released. This 40 page illustrated manual provides information on selection of proper thermocouples and protecting tubes, methods of checking thermocouples and pyrometers and installation data. It describes and lists current prices on thermocouples, thermocouple wire, lead wire, heads, connectors, plug and socket assemblies, insulators, protecting tubes and radiation heads. Temperature — millivolt curves, resistance tables, pipe and wire sizes and lead wire conduit capacity are furnished in chart form in a separate section of the book (T/C 7). Wheelco Instruments Co.

(7) Metal Treating Chemicals

A set of seven new folders is available on metal preservation and paint durability on metal. They include: "Alodine" (Protects Aluminum, Anchors The Finish); "Deoxidine" (Destroys Rusters, Bonds Paint To Metal, Removes Rust); "Duridine" (The Modern Metal Cleaner and Conditioner);

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. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Cold Spray "Granodizing" (The Protective Zinc Phosphate Coating Process For Steel); "Lithoform" (Makes Paint Stick To Galvanized Iron); "Rodine" (Efficient and Economical Pickling With "Rodine"); "Thermoil-Granodine" (For Unexcelled Protection Against Rust and Wear). Each folder describes a specific metal-treating chemical; does it briefly and thoroughly. Illustrations help the reader visualize various phases of the product and process involved. (700, 698, 704, 699, 702, 703, and 701). American Chemical Paint Co.

(8) Back-Up Roll Sleeves

A review of the operating performance of forged sleeves on back-up rolls in a variety of rolling mills, and a step-by-step description of manufacturing procedure in forging such sleeves, is now available in a 4-page folder. This illustrated folder, "Reviewing Forged Sleeves on Back-Up Rolls," also discusses the selection of proper hardness for roll sleeves and comments on the cost comparison between purchasing a new sleeve and sleeving a worn-out cast back-up roll. Heppenstall Co.

(9) Water-Hydraulic Controls

A folder with many illustrations descriptive of water-hydraulic high pressure controls has been issued. The bulletin deals with hydraulic control valves, prefilling valves, stop valves, check valves, by-pass valves, shut-off valves for hydraulic accumulators and combinations of valves for sequence operation. Hydropress valves are the development of many years of hydraulic engineering experience and have been used in numerous hydraulic plants. (L-43). Hydropress, Inc.

(10) Separation Magnets

A new four-page illustrated bulletin on separation magnets is announced. The bulletin gives detailed information on the application, construction, selection and suspension of magnets. It also contains detailed data on field attraction and penetration, magnet dimensions, weights and lifting capacities of circular and rectangular separation magnets. (F-2001). Ohio Electric Manufacturing Co.

(11) Design and Construction of Plants and Furnaces

A book is available describing the design, engineering and construction services of the Rust Engineering Company and its subsidiaries. Every step of the services available is included in the description, with views of the various types of plants and furnaces designed, engineered and constructed by this company. To the steel industry Rust offers plant layout; systems for handling and preparing materials for processing; steel plant furnaces of all types; power plants and electrical systems; industrial chimneys; plant construction; and machinery erection. This book is limited to chief engineers and combustion engineers actively engaged in the production of steel. All requests will be screened.

(12) Metal Carbides

The publication of a new, revised die and wear parts catalog is announced. This 36-page catalog contains full prices and particulars on Talide-tipped centerless grinder blades, sheet metal draw dies, wire and tube dies, bolt dies, drill jig bushings, gages and solid carbide bars, tubes and wear strips. Considerable engineering and design data is included. (48WP). Metal Carbides Corp.

(13) Wire Rope Handbook

Jones & Laughlin Steel Corp. announces publication of a new pocket-sized handbook titled "Wire Rope Is A Machine" which is available. Interestingly illustrated, the handbook gives men on the job an unusually simple and straightforward explanation of how wire rope works, how it should be operated, and how to select and order correct wire rope construction for long service life on the job. Five sections in the handbook demonstrate important features of (1) installing and operating wire rope; (2) selecting the correct wire rope for the job; (3) catalog of standard J&L wire rope constructions; (4) standard fittings, slings, and splicing service available with J&L wire rope; and (5) general recommendations for ropes in use on standard equipment. Included in the catalog section are tables of weights and strengths. (ADS151). Jones & Laughlin Steel Corp.

(14) Standard-Rated Industrial Furnaces

A new 8-page folder has been prepared to describe a line of standard-rated industrial furnaces. The booklet provides an excellent survey of the broad line of standard-rated furnace equipment. Equipment for a broad range of processes is presented, including hardening, tempering, forging, metal melting, air heating, etc. The folder provides an excellent survey of what is available in standard equipment, with designs completed and parts in stock, for rapid delivery. This equipment offers the advantage of rated performance, based upon design and extensive operating data such that the number of pounds of steel heated per hour, at a pre-determined rate of gas consumption, can be accurately specified. Providing a useful summary of an extensive line of industrial furnaces, this bulletin should be a handy reference piece for all men concerned with furnace selection. (SC-141). Surface Combustion Corp.

(15) Electrical Precipitation

A book is available describing the Cottrell process of electrical precipitation. The booklet describes three industrial gas cleaning problems. It describes recovering material of value, cleaning air or industrial gases for subsequent use, and the prevention of nuisances to the public. A thorough and concise description of how this electrical precipitator works is included in this book. Both the pipe and plate types are illustrated. Sections are devoted to the use of electrical precipitation in the following industrial locations: power plants, smelters, acid plants, blast furnaces and various other industrial plants. If you have a problem of cleaning the gases emanating from your plant, we suggest that you obtain this booklet. Research Corp.

(16) Mechanical Car Unloader

A reprint is available describing the Kinney mechanical car unloader. This reprint describes the technical operation of this unloader, which will unload a 70-ton car of iron ore in approximately 20 minutes, where formerly six men were required to do the same work in 30 to 40 minutes. The unloader has a wide application in

the unloading of coal and other materials, and is particularly effective on frozen materials. Also described is the bridge construction necessary for the use of this unloader. S. P. Kinney Engineers, Inc.

(17) All-Temperature Pipe Insulation

A folder is available describing "Foamglas" pipe insulation for cold or hot piping. The folder discusses this new insulation that can be used indoors and outdoors. Its cellular glass structure makes a highly efficient insulating material. It is ideal for use where exact temperature control is required. A tabulation is given of the various sizes available, together with list prices. Application data is also included. (AIA File No. 37-B-2). Pittsburgh Corning Corp.

(18) Handbook of Monel Metal

To help engineers cut costs, about 200 standard products for corrosive and high temperature service are listed in a new catalog available to you. This is the first complete compilation of products made of Monel, Nickel and Inconel available economically from stock or from standard designs. Among the standard specialties described and illustrated under 47 general classifications are thermocouple protection tubes, pipe and pipe fittings, gaskets, valves, cathodes, wire rope, balls, floats, nails, bolts, pickling slings and hooks, and vibration isolators. International Nickel Co., Inc.

(19) New Gasoline Truck

A bulletin is available describing the new "Lift King" gasoline truck which features fluid drive, automotive controls, hydraulic piston lift and low-mast heights with high free lifts. The booklet describes how this new gas truck, recently unwrapped after a long period of design, service testing and tooling, boasts of several features not found in similar trucks now available. The gas truck is equipped with standard Chrysler fluid drive which outmodes mechanical couplings and permits the operator to progress from slow to fast speeds without operating clutch or gearshift levers. (5101). The Yale & Towne Manufacturing Co.

(20) Boiler Books

Two books are available to you on boilers. The first is entitled, "Integral Furnace Boiler," and describes a boiler arranged for firing with either pulverized coal, alone, or in any combination. It describes how these boilers can be used for long periods of economical operation with low maintenance cost. Cutaway views and sketches adequately illustrate the boiler operation and internal design.

The other booklet is entitled "The Stirling Boiler." It describes how this boiler has met the needs of industry by furnishing continuous production of clean, dry steam. Included are diagrams showing two arrangements of boiler installations. Also shown are pulverized coal-fired arrangements at power plants in central stations and in the steel industry. Discussed are the range of applications of these boilers as well as the economies in maintenance.

If you are connected with power plant supervision, we suggest that you add these two thoroughly prepared booklets to your files. (Type FH and G62). The Babcock and Wilcox Co.

(21) Clipper Oil Seals

A folder is available describing Clipper oil seal's unique one-piece molded body which provides maximum bearing protection. The folder gives six reasons why these seals last longer and seal better. Specifications and recommendations are given with technical data and recommended dimensions. Included with this folder is a mold list showing the definite types of oil seals available with the dimensions. (PK-31A and PK-36A). Johns Manville.

(22) Cold Roll Forming

An 86-page book on cold roll forming is available to you. The book gives an illustrated story of the equipment and process of cold roll forming, and uses of its products and their advantages and commercial possibilities. It also describes auxiliary equipment for curving, coiling, ring-forming, notching, perforating, welding, embossing, automatic cut-off and other operations frequently incorporated in cold-forming production lines. The function, scope and economics of cold roll forming production lines are described in detail. Automatic flying cut-off machines are discussed and illustrated. This book will be a most valuable edition to all cold rolling supervisors in the industry. Yoder Co.

(23) Refractory Cement

A leaflet is available describing a high temperature bonding mortar refractory air setting cement for laying and surfacing fire brick. Walsh Refractories Corp.

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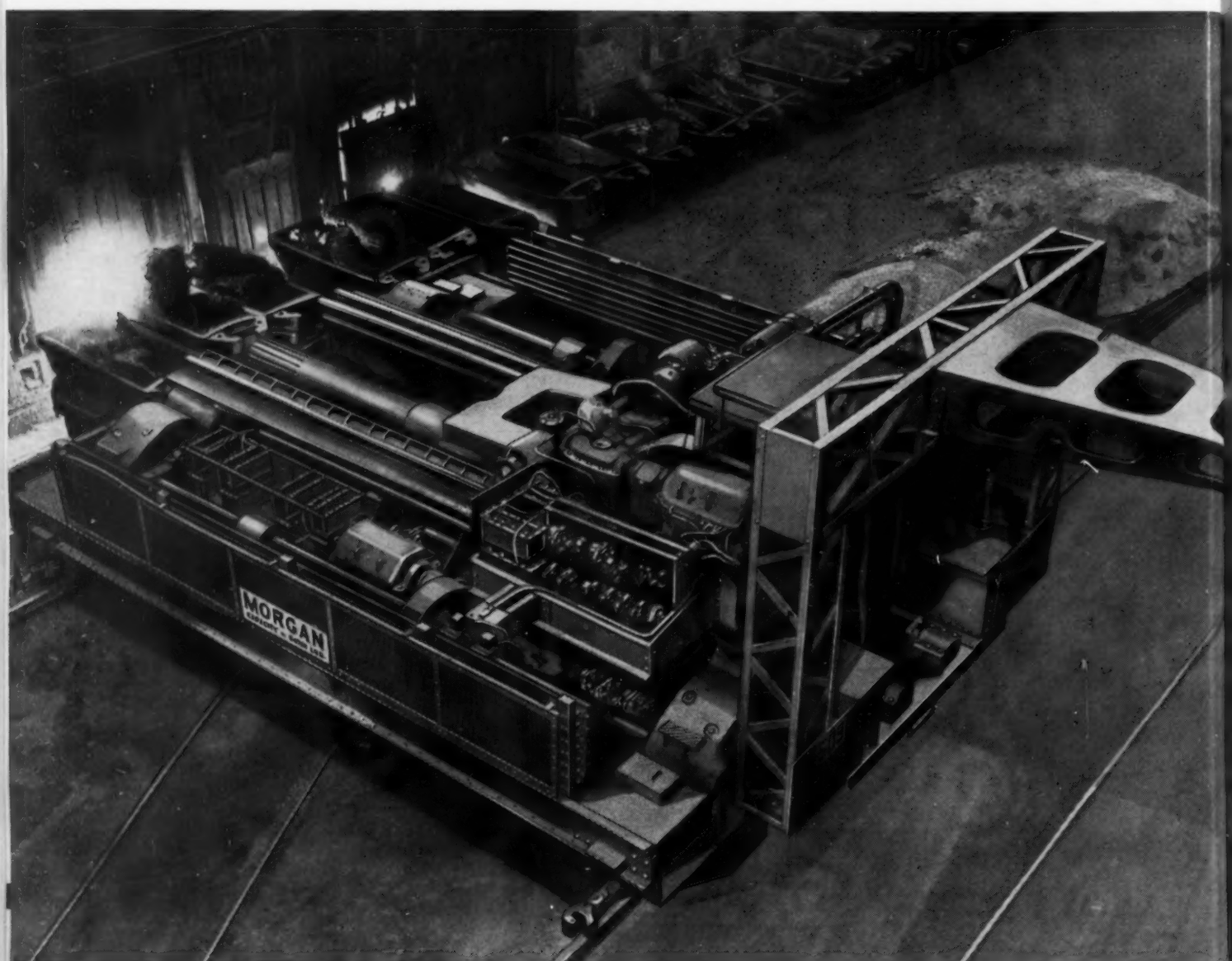
BUILT BY MORGAN Engineering

MORGAN 12-TON LOW TYPE OPEN HEARTH FLOOR CHARGER



Illustrated is one of three Morgan 12-ton 27′-0″ span Box Chargers on this open hearth floor. Trolley frame is a one piece steel casting. Girders are of heavy box section. End carriages are of fabricated welded box construction. Roller bearings are used throughout. Entire machine is of massive construction especially designed for taking heavy thrust loads. Morgan Chargers are built in a wide variety of sizes in both the low and high type to meet varied charging floor requirements.

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO. 1420 Oliver Building, Pittsburgh

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Equipment News...

BILLETEER INCREASES OVERALL PRODUCTION

▲ Pictured below are three of the four Billeteers which help to lower billet cleaning costs, reduce hazardous manpower fatigue and increase overall production in the steel and tube division of Timken Roller Bearing Co.

Four thousand five hundred tons of billets per month—54,000 tons per year per machine is a typical "Billeteer yield" in plants with multiple unit installations. Exclusive of inspection, each machine is comfortably handled by just one man during a full 8-hour work period. Tonnage varies according to condition of the steel and surface area per ton, and the average size of billets handled ranges from 6 in. x 6 in. to 12 in. x 12 in.

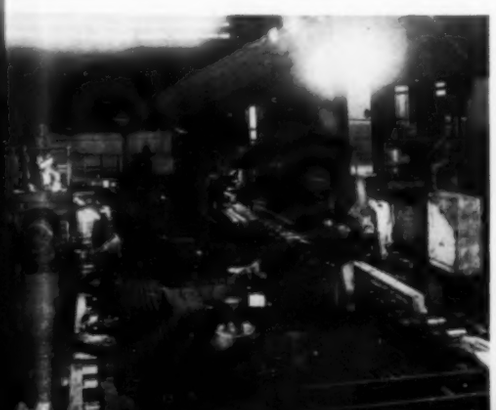
Steel production in more European plants soon is to be improved with the aid of the latest billet-cleaning equipment developed by Bonnot Co. of Canton, Ohio. One Billeteer was shipped in December and three additional 45-ton units will cross the Atlantic early this spring. Several others are already operating in Europe.

Destinations of the Billeteers include ARBED (Acieries Reuntes de Burbach Eich-Dudelange), in Luxemburg; Forges de la Providence, in Marchienne-Au Point, Belgium; Dalmine S.P.A., in Bergamo, Italy, and Nazionale Cogne, in Torino, Italy.

With the Billeteer, it is possible to cut out all classes of billet defects to any depth. This saves expensive reprocessing and gets more clean billets through to the rolling mill. Up to 1½ tons (per machine) of clean scrap of known-analysis come off billets in a day's operation. These scrap chips are 100 per cent reclaimable as good melting material. This is in sharp contrast with the recovery when torch-cleaning is employed. Extended tests on thousands of tons of billets show the Billeteer speeds up production and saves up to 56 per cent in overall chipping or cleaning costs.

Use of the Billeteer also reduced worker fatigue and physical hazards to the point where incredible safety records are established—for example, only one disabling accident in 490,000 man-hours of operation. Because Billeteers are so very easy to operate, workers no longer seek other less-grueling jobs in the plant—which sheer exhaustion forces them to do when more muscular methods of billet-cleaning are used. Production during the second half of the day equals the first part. These are all factors of prime importance where improved use of manpower, better quality control, accident reduction and greater production are required.

Three of the four Billeteers are shown at Timken's steel and tube division.



ALL-WEATHER TURBINES BUILT IN THREE SIZES

▲ Weather — good or bad — means nothing to the newest Westinghouse general-purpose turbine. Weather-protected construction and other features make the turbine suitable for all industries, indoors and outdoors, regardless of operating conditions and atmospheres, be they clean, dirty, dusty, corrosive, or moist. The turbine can operate under the worst conditions for long periods of time without excessive maintenance.

The turbine is built in three different frame sizes in ratings up to 1500 hp at speeds up to 7000 rpm. Maximum steam conditions are: inlet pressure 1500 psi, temperature 950 F, and exhaust pressure 300 lb.

The turbine support is an adaptation of the center-line type generally employed for central-station machines. The turbine has two supports: a rigid one at the coupling end, which anchors the unit but permits radial expansion of the casing, and a flexible one at the governor end, which flexes readily in an axial direction only. Because these supports are not a part of and are some distance from the turbine cylinder, their temperatures and hence dimensions vary little. As a result, alignment of the turbine shaft to the driven machine is maintained regardless of change in operating temperature. Maintenance of alignment is further enhanced by transmitting piping thrust to the foundation with a minimum of casing distortion.

An interesting feature of the turbine is dual overspeed protection. Normally, overspeed protection is provided by a single valve (operated independently of the main governor) that closes when speed becomes excessive. As this valve may not operate for long periods of time, under adverse conditions it may stick and fail to close when the need arises. Hence, as an added safety measure, dual-protection was arranged, which closes the governor valve as well as the overspeed valve. The two valves function independently of each other.

Other features of the type-E turbine are corrosion-resistant casing glands that do not deteriorate during long period of idleness.

REDESIGN EXCHANGER FOR BETTER USE

▲ Recently announced is National Carbon Co.'s "Karbate" seven-tube Impervious Graphite Shell and Tube Heat Exchanger, Series 70A, as a redesign of the previous Series 70, thus augmenting the usefulness of this exchanger. The basic elements of the new unit may be converted from a single pass to a double pass unit by a simple change of covers. The exchanger can better be adjusted to varying rates of flow and amounts of liquid handled. This feature gives the unit added utility without affecting its original efficiency.

Replacement of tubes may now be made quickly and easily in the field, thus eliminating the necessity of blocking off tubes and thereby reducing capacity. Two sizes, having effec-

tive outside tube areas of 16.4 sq ft and 24.6 sq ft are carried in stock.

"Karbate" Shell and Tube Heat Exchangers, Series 70A, are manufactured by National Carbon Co., Inc.

DESIGN LUBRICANT TO ELIMINATE CHATTERING

▲ An entirely new product designed specifically for the lubrication of industrial tableways has been developed by the Beacon Laboratories of Texas Co. An important addition to the cutting tool industry's lubricant needs, the new product enables Texaco now to supply a complete lubricant service for all machine tool work.

To be called Way Lubricant D, the new product is designed for use on all kinds of ways—hardened steel, chilled cast iron or the new laminates. An extended series of field experiments have proved that use of the new lubricant will eliminate the chattering and jumping effects that occur at the beginning of the tool stroke.

Compounded with special additives, the new product will not squeeze or press out, either when the machine is in motion, or standing still. Thus, the oil film on the way remains constant and desired precision may be maintained. It is non-corrosive to steel and copper and will not plug filters. It possesses low static and running coefficients of friction and the required tackiness.

This product is the result of several years of research, and is being marketed only after extended experimentation and consultations with machine tool users.

AIR-ELECTRICAL CONTROL OPTIONAL PRESS FEATURE

▲ Air-electric control has been adopted as an optional feature available for all "Steelweld" presses manufactured by Cleveland Crane and Engineering Company.

With this control an air cylinder does the work of throwing in the clutch which ordinarily is done by a mechanical foot-operated treadle. The air cylinder can be actuated by hand button, foot switch or various combinations of both.

Air-electric control eases the operator's work and speeds production of large orders of duplicate parts. It is especially advantageous in cutting costs when several hundred or more parts are produced at a time. It provides genuine safety when two or more men work simultaneously on a press, permitting operation only when all operators are ready.

A selector is usually incorporated in an air-electric control circuit to provide various ram movements such as long stroke, short stroke, continuous operation and inching. For instance, it may be set to stop the ram on the down stroke just before the upper die reaches the lower one, or it may stop the ram at the top of each stroke.

Figure 1 shows the air-electric con-

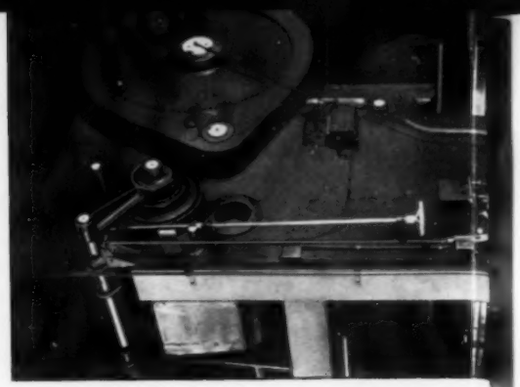


Figure 1 — View of air-electric control mounted on left end of a "Steelweld" press.

Browning Mill Type Cranes are built in accordance with A. I. S. E. specifications. They incorporate the types of motors and controls on which your mill or industry has standardized. This flexibility adapts your VRB crane *perfectly* to your needs. Only the finest materials are employed. Browning heavy duty cranes meet the most rigid demands and satisfy the most critical users. Our design, placing plenty of strength wherever needed, is the outgrowth of 48 years' experience in the crane industry.

"Built as you yourself would build them"

Write for our Bulletin "S".

VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

LOOK TO THE FUSE LEADER FOR PRODUCTION PROGRESS

Double Fibre Bridge Assembly
Increases Strength 10 Times

WARE HI-LAG Fuses have the strongest, most rigid knife blade assembly ever designed in fuses. The two heavy fibre bridges are supported by sturdy brass brackets which add greatly to the strength of the assembly. These bridge supporting brackets are attached to the copper knife blades and contact the entire end of links so that current flows through the brackets as well as the blades over a large area. Another reason for WARE HI-LAG Fuse's cool operation.

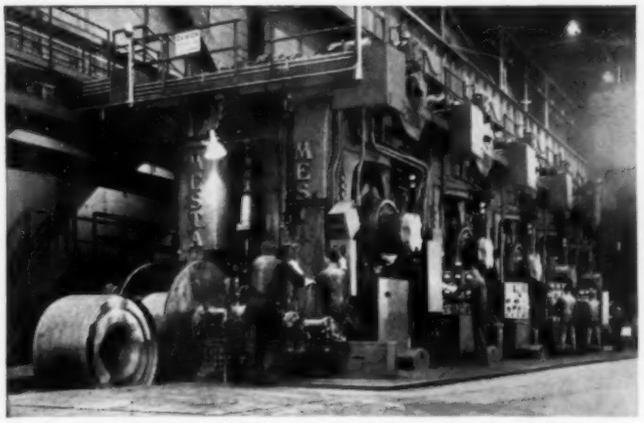
Approved by Underwriters Laboratories
Write for descriptive Circular

WARE FUSE CORPORATION
4460 W. LAKE ST. CHICAGO 24, ILL.

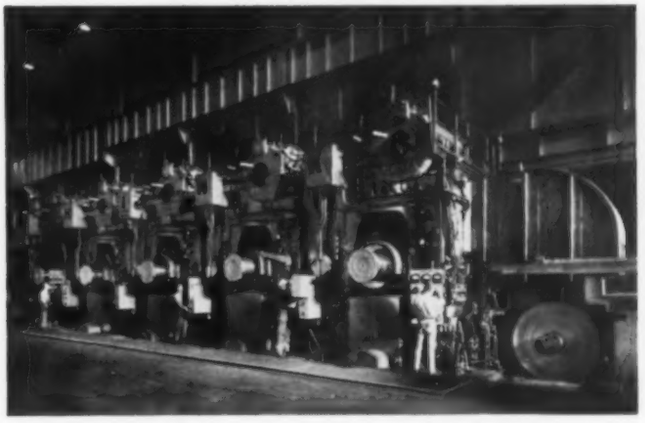
Torrington Bearings

Put on the Pressure

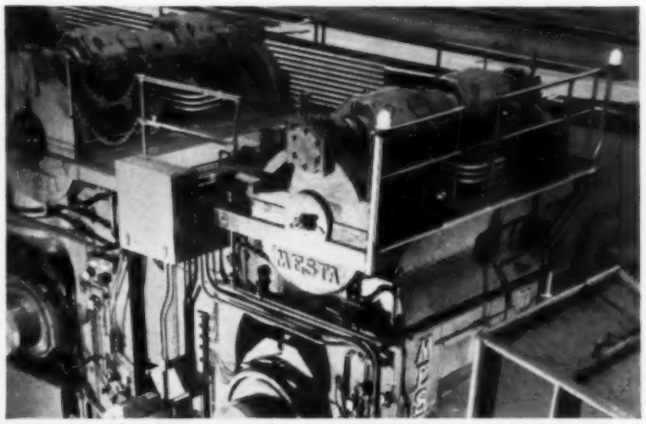
in Record-breaking Steel Mill



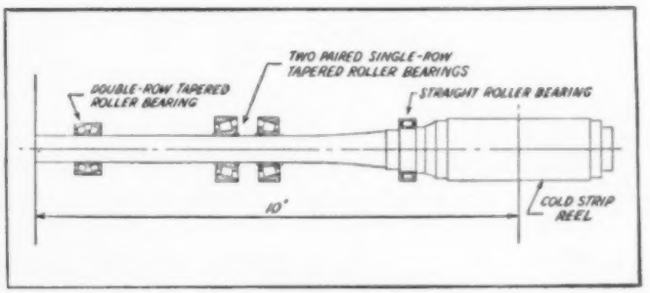
To roll strip fast is to roll it fine—in quality and uniformity. So, to make better strip, Mesta Machine Company designed and built the new Jones & Laughlin tandem strip mill for record speed—6,250 fpm. And it's equipped for top performance with Torrington Bearings on work rolls, screw downs and take-up reel.



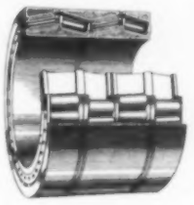
The pressure that reduces strip from 1/11" to 1/100" at *more than a mile a minute* imposes extreme loads on Work Roll Bearings. The design and high capacity of the Torrington four row Tapered Roller Bearings enable them to give exceptional service at this high speed despite tremendous radial and thrust loads.



The mill screwdowns bear down on back-up rolls through Torrington heavy-duty Thrust Bearings, Type LR. The smooth operation and low starting torque of these bearings helps make the screwdowns the fastest in response action and the speediest ever installed on a tandem mill.



The take-up reel is of the mill-tested design shown here in cross-section, equipped with Torrington single and double-row Tapered Roller Bearings. Supporting the reel at one end only, the bearings are designed for maximum radial and thrust capacity to maintain high tension on the strip.

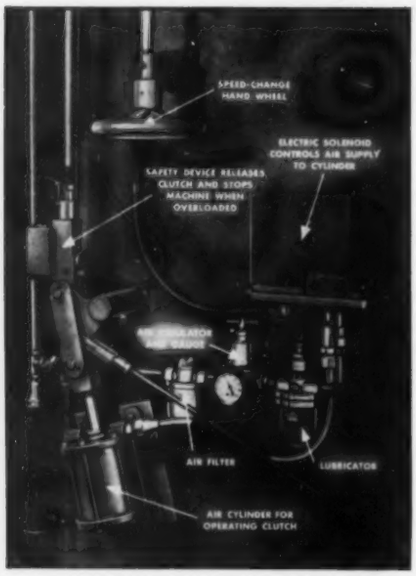


The exceptional service delivered by Torrington Bearings is based on our years of experience in designing, building and applying all major types of anti-friction bearings. For engineering assistance from design to maintenance, contact our nearest office. THE TORRINGTON COMPANY, South Bend 21, Ind., or Torrington, Conn. District offices and distributors in principal cities.

TORRINGTON TAPERED ROLLER **BEARINGS**

Spherical Roller • Tapered Roller • Straight Roller

Needle • Ball • Needle Rollers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ELECTRIC SOLENOID CONTROLS AIR SUPPLY TO CYLINDER
SAFETY DEVICE RELEASES CLUTCH AND STOPS MACHINE WHEN OVERLOADED
AIR FILTER
LUBRICATOR
AIR CYLINDER FOR OPERATING CLUTCH

Figure 2 — Close-up view of air cylinder and component parts.

trol equipment mounted on the left end of a Steelweld press. Clutch and brake are near top of the machine and are operated by a common shaft that is equipped with a heavy spring that normally keeps brake engaged. This shaft is moved by the air cylinder through a long vertical rod to a toggle joint.

Figure 2 is a close-up view of the air cylinder and component parts.

SPECIAL SCOOP HANDLES LOOSE MATERIALS

▲ An electric power industrial truck equipped with a special type of scoop is announced by Elwell-Parker Electric Company. This is for picking up, transporting, delivery or piling loose materials used in many manufacturing and construction operations.

The scoop is attached to the truck's tilting and elevating mechanism and all controls are centralized at the driver's station. A simple tripping device on the scoop provides for rapid discharge of the load. It also has a pneumatic snubber to cushion impacts. When the scoop is lowered to floor level it assumes its normal shoveling position. Providing for ready adjustment to local conditions, the truck's upright column may be tilted forward 5 degrees from perpendicular. For safe carrying of the load and to avoid spillage, the upright column may be tilted backward 15 degrees from perpendicular. Flexibility of the machine facilitates loading or emptying the scoop at floor levels or at any height up to 117 inches.

Capacity area of the scoop is 12 cu ft; capacity weight of load is 2000 lb. Speed of the truck with load ranges up to 5¼ mph.

The combination of lift truck and scoop is especially adaptable in plants or areas where bulk materials are handled, such as related to chemicals, paints, glass, cement, coal, sand; and also in metalworking industries where large quantities of metal chips and similar scrap must be moved.

The scoop is interchangeable with a standard type fork, thereby adapting the truck at any time to a still wider range of time-saving, load-handling purposes.

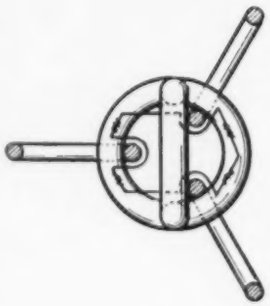
ANNOUNCE NEW LINE OF HARD FACING ALLOYS

▲ Air Reduction Sales Co. has announced the immediate availability of a complete new line of hardfacing alloys bearing the famous Airco trademark.

Divided into three primary groups, ferrous alloys, cobalt base alloys and tungsten carbide, there are a total of

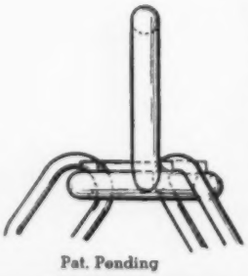
...LONGER LASTING
MAGNET CHAINS

The use of heat-treated high alloy steel throughout suspension makes periodic annealing unnecessary.



Reduce Breakdown Time!

Our FRICTIONLESS chains last up to 3 times as long as old-style suspensions. Write for prices. Prompt shipment from stock.



Ring plate keeps chain separated. Eliminating twisting and rubbing, and keeps magnet level.

Suspension chain for 55" magnet tests to 89,000 pounds.

Suspension chain for 65" magnet tests to 115,000 pounds.

Pat. Pending

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SAFER, FASTER MARKING with the SAFETY BOX TYPE HOLDER

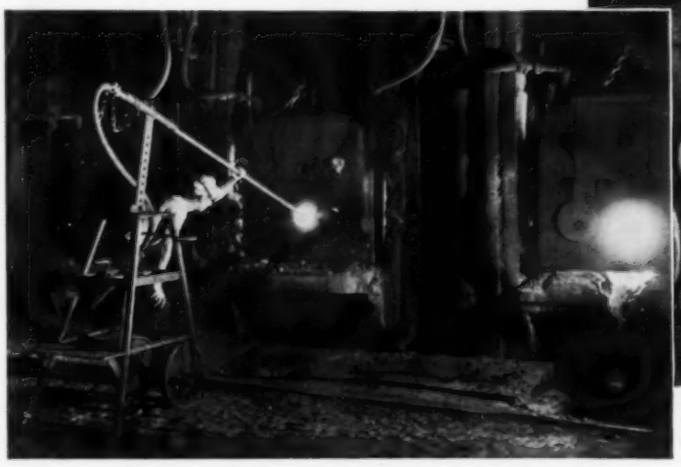
The Safety Box Type Holder for safe and efficient marking of hot or cold, flat, round or angular surfaces—is made of one piece of Safety steel with welded handle, for heavy duty service. Outer sleeve holds type holder at right angles to surface, assuring perfect impressions. Type is quickly and easily changed.

• NO MUSHROOMING • NO SPALLING
• BETTER MARKING • LONGER SERVICE LIFE

Write for Complete Data

M.E. CUNNINGHAM CO.
SAFETY STEEL STAMPS
105 E. CARSON STREET PITTSBURGH 19, PA.

Oxygen measurement is a routine job for HAGAN RING BALANCE FLOW METERS



Most problems of oxygen measurement in steel mills are due to the sudden and wide fluctuations in oxygen use. In open hearth applications, for example, there may be a comparatively low and steady flow of oxygen for relatively long periods of time together with tremendous surges of comparatively brief duration.

In applications of this kind, the meter must measure accurately at low flows, must respond quickly to all fluctuations, and must have sufficient range to measure peak flows.

The Hagan Ring Balance Meter meets these requirements without difficulty, giving an accurate and easily-read record on a standard 24-hour chart, and also, if desired, continuously totalizing the flow. All of this is accomplished with a standard model, single-ring meter, equipped with a simple mechanical integrator.

If you want a temperature or pressure record, or temperature or pressure compensation, there is a **standard** Hagan Ring Balance Meter which will give you either or both. Temperature, pressure, compensated flow and uncompensated flow can all be recorded on a single chart. The integrator automatically totalizes compensated flow.

Measurement of oxygen flow is only one application of these extremely versatile meters. For full information, mail the coupon below, or write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

HAGAN CORPORATION

METALLURGICAL FURNACE CONTROL SYSTEMS

RING BALANCE FLOW AND PRESSURE INSTRUMENTS

BOILER COMBUSTION CONTROL SYSTEMS

HAGAN HALL BUROMIN CALGON

Hagan Corporation
Hagan Building
Pittsburgh 30, Pa.

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ISE-2

fifteen hardfacing alloys available. According to the manufacturer, this is the largest, most complete line of hardfacing alloys on the market today. Especially developed to combat abrasion, impact, heat and corrosion, the new hardfacing alloys will increase the work-life of your equipment from two to twenty-five times.

In order to stimulate the introduction, the manufacturer is making a special offer of a trial assortment of alloys. The assortment consists of: The new "Aircolite" hardfacing alloy especially recommended for equipment subjected to severe abrasion and medium impact such as pulverizer hammers and core crusher rolls (for oxyacetylene) and electric arc application).

The new Airco self-hardening alloy for equipment is subjected to severe impact and abrasion such as bucket teeth and sizing screens (electric arc).

This trial assortment is being made available at the special price of $2.95. According to Airco, the assortment contains a sufficient quantity to assure an adequate performance test. Also included in the trial offer package are instruction sheets for each of the two alloys plus a comprehensive descriptive booklet covering the entire hardfacing line.

To receive your trial assortment of Airco's new hardfacing line send your check for $2.95 to Air Reduction Sales Co., 60 East 42nd St., New York 17, N. Y., or to the Airco sales office nearest you.

WELDING FURNACE HAS UNIFORM HEATING

▲ Perfect timing and uniform heating are two important factors governing low-cost, efficient production at American Fork & Hoe Co.'s plant in Ashtabula, Ohio. At this point of operation, hundreds of forks, in various sizes, roll from the production line each day.

The Gas Machinery Co., Cleveland, recently designed and installed a special oil-fired rotary hammer welding furnace carrying thermal heads upwards of 2900 F to heat work to 2300 F at high speed. The unit provides fast, localized heating, which is a must in the split-second heating process necessary in this continuous operation.

Gas Machinery rotary furnaces are built in various types and engineered for specific applications of forging, tempering and clean heat treating. Each furnace is carefully designed to require the least possible operating labor and to reduce maintenance costs.

The American Fork & Hoe Co., producers of a variety of items, including sledges, hammers, garden tools, rakes and hoes, has production facilities in Geneva, Ashtabula and Conneaut, Ohio; Charleston, W. Va.; Evansville, Ind., and in Canada.

EQUIPMENT INCREASES BROOKS CAPACITY

▲ In a recent expansion program at the Cleveland, Ohio, plant, Brooks Oil Co. added six new mixing kettles for the manufacture of "Leadolene" lubricants. This installation included Struthers Wells power agitators. With the addition of the new equipment the output of this lubricant has been doubled.

RAILROAD SIDING LIKE THIS PAYS OFF!

GOOD railroad siding, like that pictured above which we constructed for Sears, Roebuck & Co., pays off in the elimination of costly delays and the speeding up of traffic. Proper construction and maintenance of railroad siding is an insurance invaluable to you.

We are staffed and equipped to survey your track layout, recommend and execute a complete program of repair, rehabilitating and future maintenance. We'll be glad to consult with you at your convenience.

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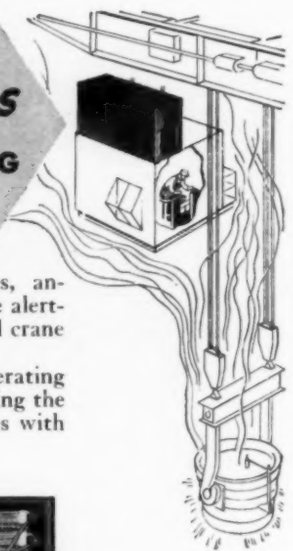
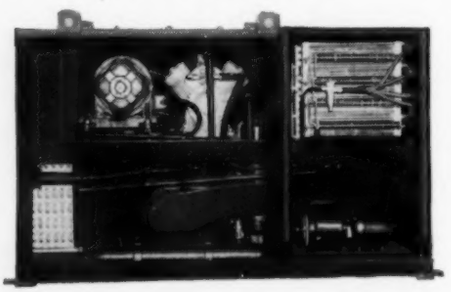
DRAVO CRANE CAB COOLERS REDUCE OPERATING HAZARDS



● Excessive heat, obnoxious fumes, annoying dust and moisture reduce the alertness and efficiency of your hot-metal crane operators.
● You can eliminate these crane operating hazards by completely air conditioning the cabs on all types of hot-metal cranes with Dravo Crane Cab Coolers.



Completely self-contained Dravo Crane Cab Cooler requires electrical connection only.

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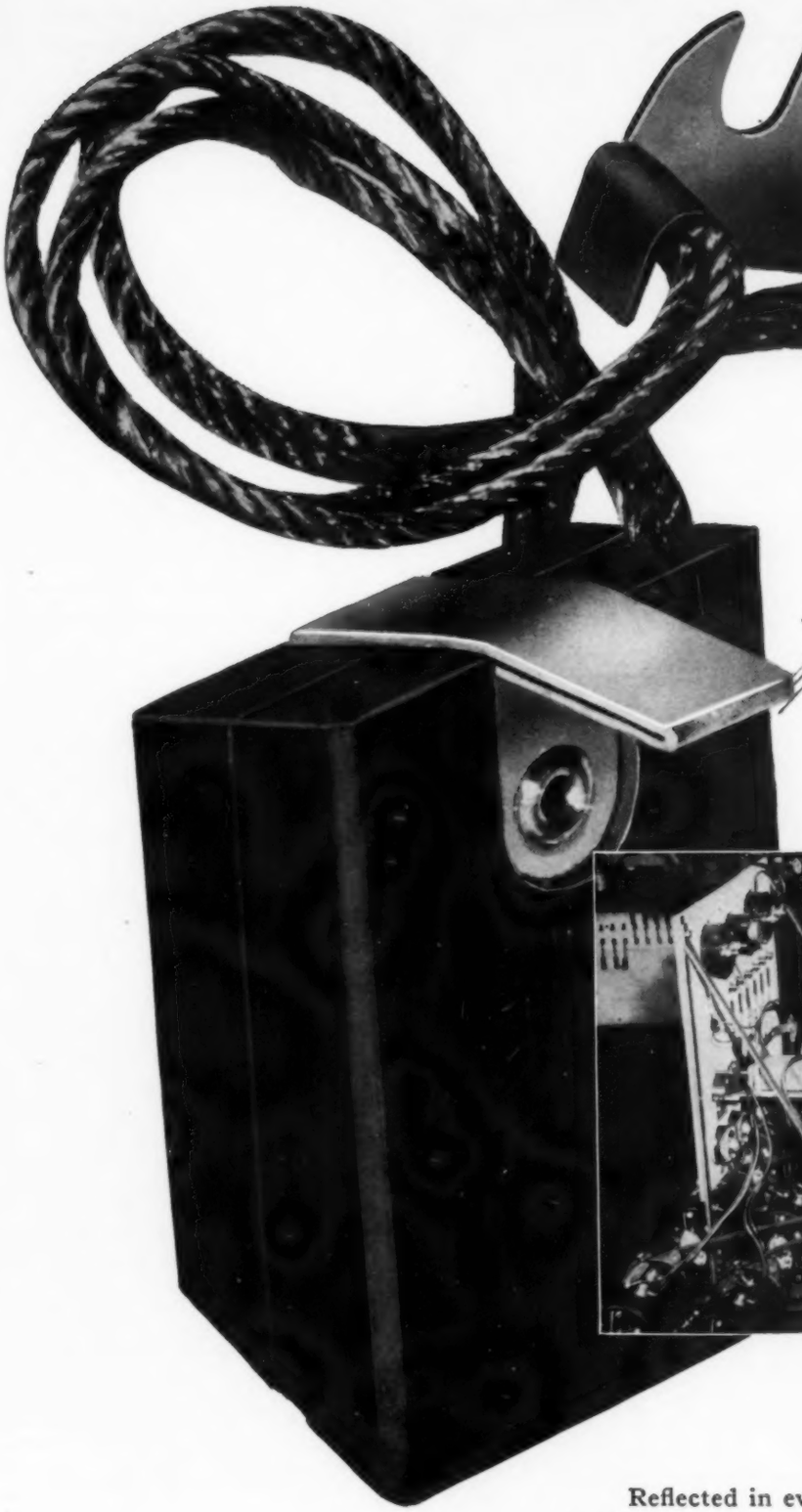
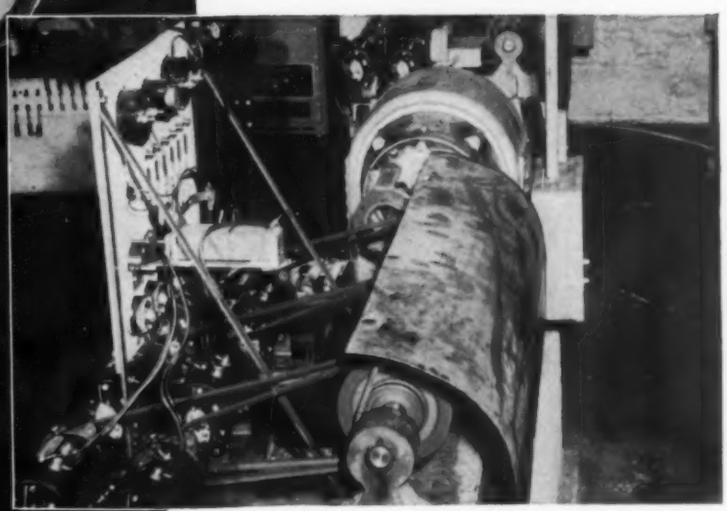


Speer carbon brushes REFLECT years of research



Typical of Speer Carbon Company's electrical laboratory equipment is this Speer-Developed Automotive Brush Testing Apparatus.

Reflected in every Speer carbon brush are the results of 50 years of research – advancements that have kept pace with industry's demands for better commutation, through modern, fully equipped and completely staffed laboratories – part of Speer Carbon Company's highly developed organization.

These complete facilities are available at any time to devote attention to your present or future requirements.

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brushes • contacts • welding electrodes • graphite anodes • rheostat discs • packing rings • carbon parts

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Six new mixing kettles recently installed at Brooks Oil Co.'s Cleveland plant.

An automatic filler for drum products was also installed at Brooks, permitting the shipping of pre-specified quantity per drum. This prevents varying amounts of lubricants from drum to drum. It also facilitates both shipping and receiving, materially reducing required record checking by both manufacturer and customer.

The new automatic filler permits the shipping of drum products in pre-specified amounts.

STEAM IS USED FOR SCALE-FREE TEMPERING

▲ Scale-free tempering and strain relief of metal parts is now being performed to an increasing extent by the steam "Homo" method, recently developed by Leeds and Northrup Company. High-speed steel tools, cast iron, sintered powdered iron compacts and non-ferrous alloys are being treated by this method at temperatures up to 1150 F.

By adding a protective steam atmosphere to the well-known Homo forced-convection heating and its "Micromax" temperature control, the method, reports indicate, is enabling heat-treaters to turn out steel parts with a uniform blue oxide finish. Parts are free from scale, have improved machinability, increased resistance to corrosion and wear, and are easier to clean for subsequent plating. High-speed tools, for example, exhibit improved life when cutting hard or abrasive materials. Powdered iron parts, after steam treating, have greater density and hardness.

Steam from a process line or a small boiler is fed into the work chamber through an inlet in the bottom of the furnace. Although especially designed for steam tempering, the furnace can also be run with natural air atmosphere, like any conventional "Homo" tempering furnace.

ADD MELTING FACILITIES IN BRACKENRIDGE PLANT

▲ At the request of several large consumers, Allegheny Ludlum Steel Corporation has agreed to install and operate for them new melting facilities at its plant at Brackenridge, Pennsylvania.

The new facilities will comprise three electric melting furnaces, new

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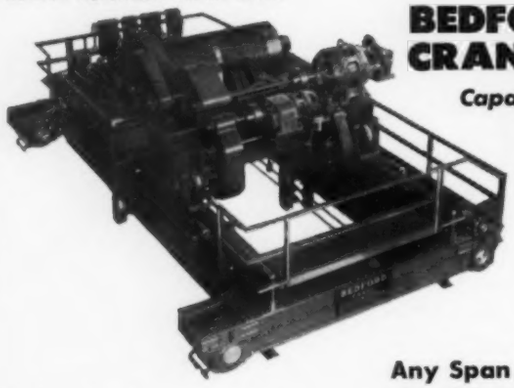

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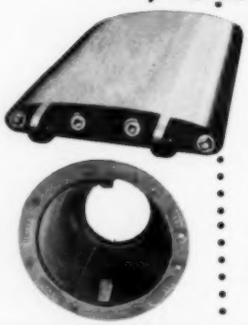
Plus THAT "SOMETHING EXTRA"



THEY ARE PRODUCED by a skilled personnel, sensitive to your desires, working in an environment of enthusiasm and teamwork. Falcon's personnel is adaptable, flexible, highly integrated and coordinated and adequately supported with the most modern equipment and methods, and supplied with the best of metals.

Another "SOMETHING EXTRA" is provided in Falcon's PROMPT DELIVERY. Dependable for 59 years.

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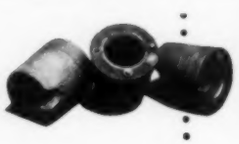

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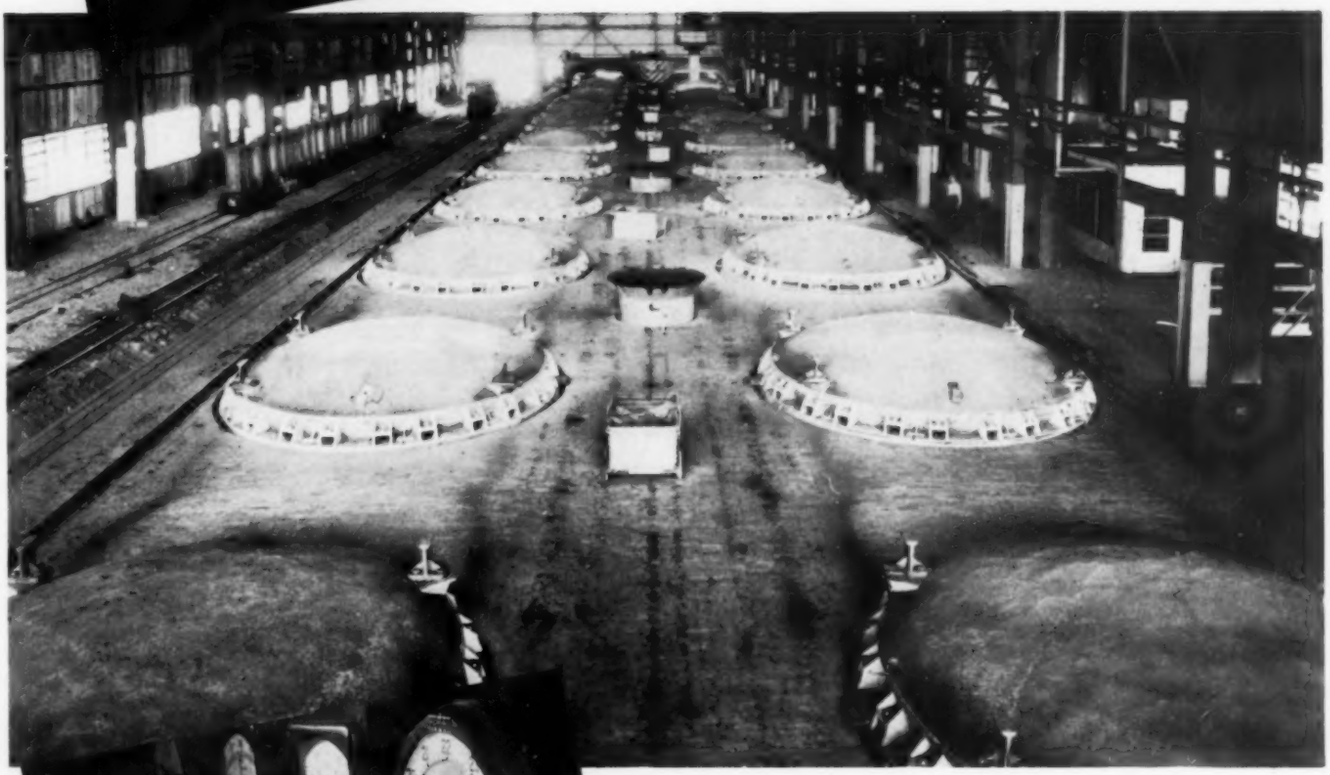
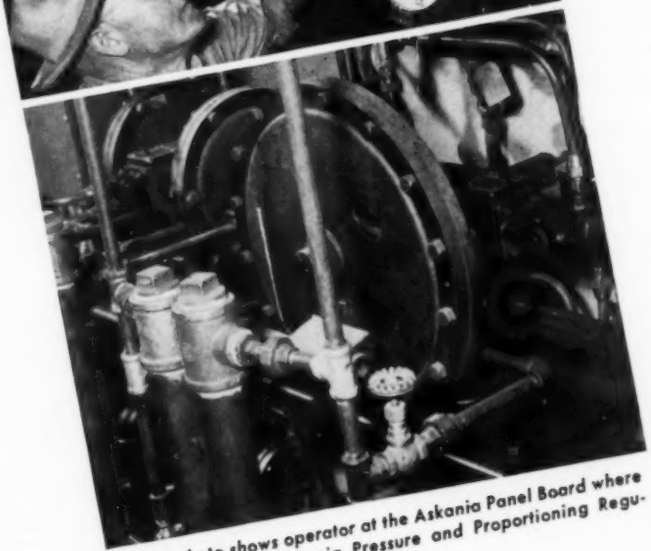




Upper photo shows operator at the Askania Panel Board where controls are set. Askania Pressure and Proportioning Regulators are shown installed, (below).

for C. F. and I.'s 24 Pits
at Pueblo, Colorado

These new soaking pits at the Pueblo, Colorado, plant of The Colorado Fuel and Iron Corporation are responsible for a huge supply of ingots being properly conditioned for rolling. Designed and installed by the Salem Engineering Company, the pits depend on accurate automatic controls to assure uniform operation for constant quality.

All pits are equipped with Askania combustion control maintaining proportion between fuel and air and furnace pressure for each of the twenty-four pits. All controls, together with supervising instruments, are mounted on Askania panels.

For efficient ingot processing in every stage before rolling, depend on Askania Controls. They are simple, accurate, reliable and long respected throughout the Steel industry.

Bulletin 116 gives full details. Send for your copy today.

ASKANIA Controls

ASKANIA REGULATOR COMPANY
a subsidiary of General Precision Equipment Corporation

240 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

soaking pits and auxiliary equipment and, while mild steel supplies are stringent, will be used for the production of carbon steel ingots. The melt shop will be made up of two swing-top electric arc furnaces of 70-ton capacity and one furnace of similar construction with a capacity of 60 tons. The 70-ton furnaces are now under construction and are being purchased outright, while the smaller furnace is being acquired from the U. S. Government on a 15-year lease.

When producing carbon steel, the combined annual rated capacity of the furnaces will be in excess of 300,000 ingot tons. The furnaces and soaking pits are scheduled to be ready for production during the second quarter of 1949 being ready for use almost simultaneously with the plant's new 40-in. blooming mill.

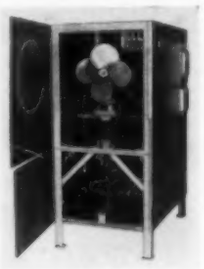
Cost of the new facilities, including rental of the Government furnace, is estimated at about $5,500,000. The new project is over and above the company's announced five-year $26,000,000 plant improvement and modernization program scheduled for completion in 1951.

DEVELOP RECTIFIER WITH LOW VOLTAGE

▲ A newly developed low-voltage high-amperage rectifier is now on the market which is suitable for supplying direct current for a number of industrial processes including: electroplating and cleaning, electrolytic production of aluminum hydroxide for water purification processes, and production testing of d-c motors and equipment.

The specifications for the unit are as follows: a-c input is 440 volts, 3-phase 50/60 cycles; d-c output voltage is continuously variable from 0 to 6; d-c output is 2400 amp continuous rating; type of circuit is 3-phase wye connected to selenium rectifier stacks; and type of cooling is forced air from two 3-phase ⅙ hp ball bearing motors.

Overload protection is given by fused safety switch, magnetic contactor with thermal overload trip mechanism, air switch to guard against failure of fan motors or blocking of air passages, fuse protection for control devices and wiring, and thermostats to disconnect rectifier in the event of over-heating of rectifier stacks. Dimensions are 31 x 48 x 71 in., and unit weighs 2100 lb.

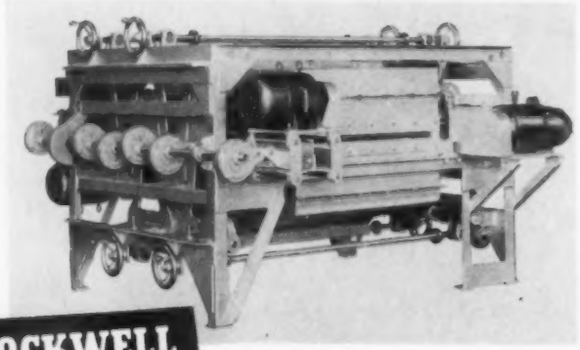


Other features include more rectifier plate area (4.05 sq in. per amp), and because the variable voltage transformer is motor driven, the output voltage can be adjusted from remote locations or made to respond to automatic controls.

The unit is manufactured by the Electronic Rectifier Co., Inc.

When you request more information say you read it in the IRON AND STEEL ENGINEER

For Your Strip Mill



ROCKWELL BRUSHING MACHINE

Provides a continuous, speedy cleaning of steel or non-ferrous strip, for removing thin scale, loose zinc oxide, carbon and foreign matter. The strip, in single broad width or multiple narrow widths, bears against the back-up roll, motor driven at same speed as the moving strip. Tampico adjustable brushes rotate in direction opposite to strip travel and oscillate so as to prevent strip from wearing each brush. Wringer rolls at both ends of the tank wring off acid and clean water.

During brushing, strip is constantly sprayed and loose material is drained off. (The set-up can be arranged for dry brushing.) A hot water rinse is also provided. Designed to your strip cleaning requirements.

Rockwell also builds batch and continuous furnaces, coil boxes, coilers, strip stitchers, pickling tanks and machines, dryers, ovens and special equipment.

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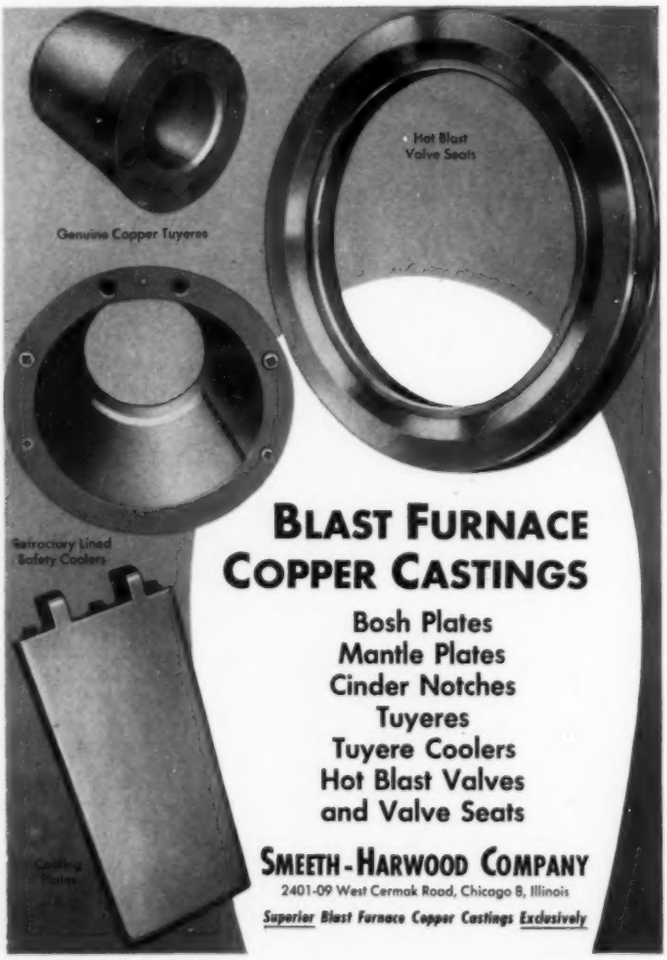

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Book Reviews

▲ "Mathematics at Work," by Holbrook L. Horton, 728 pages, 6 by 9 in.; 196 drawings and diagrams is published by The Industrial Press, 148 Lafayette St., New York 13, N. Y. Price $6. This book is a working manual intended for machine designers, tool engineers, gage designers, mechanical draftsmen, technical or trade school students, and teachers. The practical applications of arithmetic, algebra, geometry, trigonometry, and logarithms are illustrated by a wide variety of mechanical problems taken from actual practice. These problems are analyzed and solved in an easy-to-follow, step-by-step procedure.

A reference section consisting of five chapters provides a concise but clear review of the practical fundamentals of arithmetic, algebra, geometry, trigonometry, and logarithms, so that where basic principles or formulas are used in the problem solutions they can be immediately referred to if necessary.

To round out the book as a complete working manual, 145 pages of standard mathematical tables, including logarithmic and trigonometric tables, are included.

▲ This fourth edition (Dec., 1948) of A.S.T.M. Standards on Paper and Paper Products contains all of the 77 specifications and tests methods on paper and paper products which have been developed through the work of several technical committees of the American Society for Testing Materials, particularly Committee D-6 on Paper and Paper Products. There are also a number of standards of Committee D-9 on Electrical Insulating Materials. Copies of this 286-page book, in heavy paper cover, can be procured from A.S.T.M. headquarters, 1916 Race St., Philadelphia 3, Pa., at $2.50 each.

▲ Practical information on the essential properties and proper use of automotive antifreezes and cooling systems is given in the new booklet "Automotive Antifreezes" just issued by the National Bureau of Standards. This publication, although designed primarily for the average automobile owner, should prove helpful to manufacturers interested in entering the field of antifreeze production.

Included are the results of years of extensive tests at the Bureau as well as a summation of the work of other investigators. In addition to simulated and actual service tests of antifreezes, basic investigations of the physical and chemical properties of antifreeze compounds and of materials currently used in cooling systems were made. Answers are given to such practical questions as when to install an antifreeze, what strength to use, what kind of antifreeze is best suited to the service involved, how the automobile should be prepared for antifreeze, how to distinguish between different types of antifreezes, and when to replace an antifreeze. Pertinent physical properties and service performance of the major categories of antifreezes are also given.

NBS Circular 474, "Automotive Antifreezes," consisting of 16 large two-column pages, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at a cost of 15 cents a copy.

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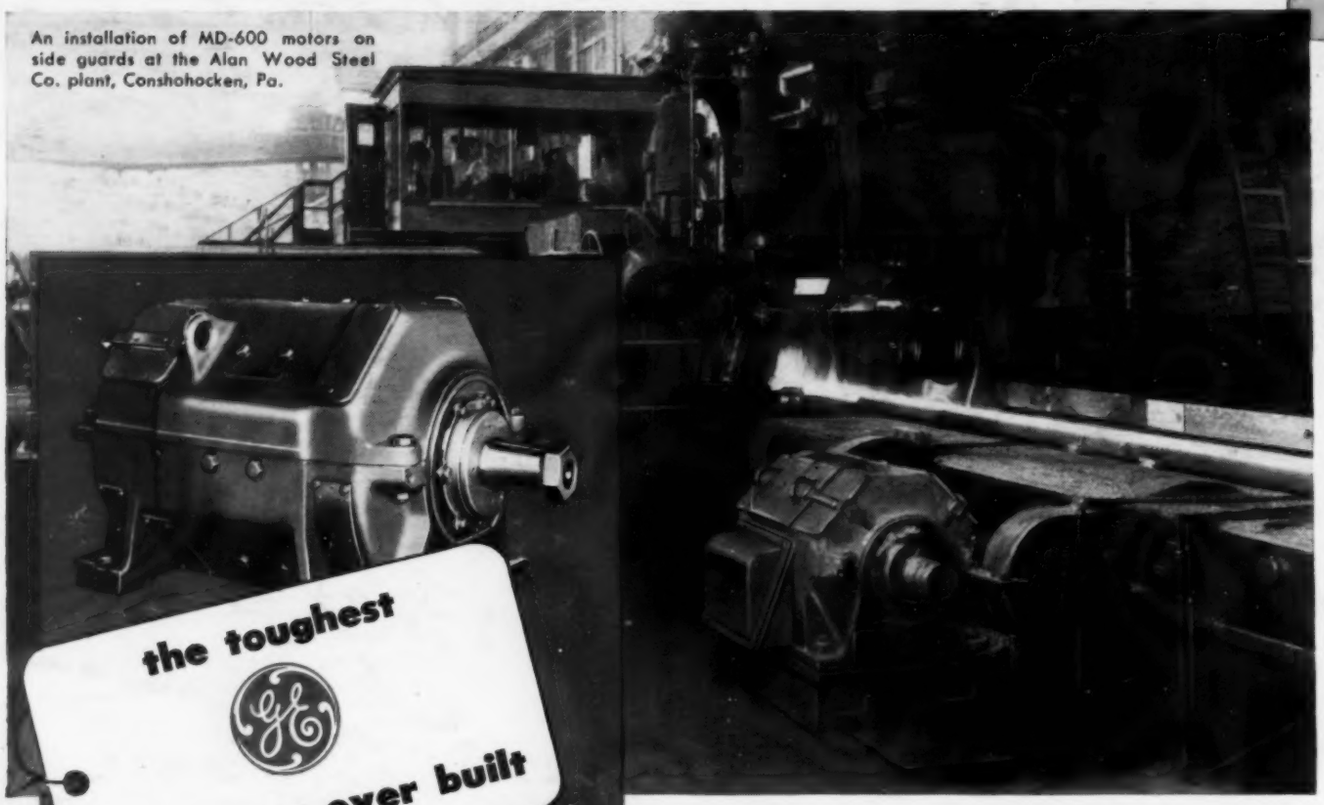

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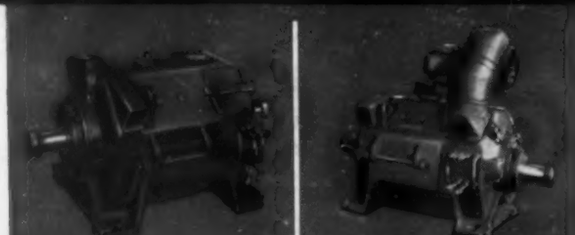

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